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Erratum for Volume XXVII.

Page 388, line 6, for Java read Jena.

Errata for Volume XXVIII.

Page 119, line 6 from the bottom, erase the words: "by the means shown in plate V."

Page 281, line 8 from the bottom, from "reproduced" read represented.

Yours Truly
A. Winchell

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SKETCH OF THE LIFE AND WORK OF AUGUSTUS WING.

By HENRY M. SEELY, Middlebury, Vermont.

PORTRAIT.

In this loving record of a portion of the life and work of the reverend Augustus Wing, the writer can scarcely proceed without at once calling attention to two facts that come incidentally into the story. The first of almost universal recognition is that the science of geology up to a very recent date has largely been wrought out by persons engaged in teaching. Their results have in the main been made possible by the wise husbandry of school vacations together with the economical use of hours between exacting class-room duties.

The preparation of an address that fellow-workers will care to remember, or of papers which they will care to read and re-read are the results of long time and labor, and these contributions represent only a fraction of what they have really accomplished. This labor of love may properly be regarded as an overflow. The field of science has been made fertile by this irrigation.

Exceptions, indeed, there are that at the same moment startle, inspire and depress, as when some favored genius sends forth in quick succession notable contributions to science. This is the exception; the rule holds. The rare occasional papers have been the revelation of thoughts and researches of well filled hours coming between lecture and lecture, or left over from other professional work.

The other fact of rarest recognition is that science may be the richer from the good service rendered by one who never made a popular address nor presented to society or editor a valuable scientific paper.

The subject of this sketch, the reverend Augustus Wing, was born at Rochester, Vermont, November 19, 1808.

We need not go far back to establish the character of the stock. James Wing, of Hardwick, Mass., the grandfather, was a member of the "Committee of Correspondence" in the early days of the American revolution. The father, also James, was a volunteer from Hardwick in the second war with Great Britain.

To the home of the first James, the grandfather, came thirteen children. The third son, the sixth of the family, named for his father, grew to early manhood in Hardwick. He was noted for great ingenuity and sturdy self-reliance, qualities much needed in those days of pioneer life. This James, with other enterprising men, found his way to Rochester, where for a little he spent his summers. When, however, the place at Rochester had in part been prepared as a home, he with his young wife, Hannah Wetherbee, in the spring of 1804, left Hardwick for a permanent place in Rochester. It was a horseback journey they had. Blazed trees marked the way to what was to be their home nest, husband and wife each carrying a fledgling perched on the saddle.

To the two sons brought from Hardwick was added the third, Augustus, at the above-mentioned date, November 19, 1808. Other children, sons and daughters came to the family, until the number in all was eleven.

The children enjoyed such school privileges as Puritan pioneers were always and early accustomed to give. The father of Augustus prized the advantages of higher schools of which he had been deprived in part, and he looked with favor on the plan of the son when he proposed to carry his studies beyond the range which the home school afforded. On the other side of the Green mountains, to the west, settlements had been made, earlier than that at Rochester; the comforts and privileges of such life had outrun those of the eastern side. High schools and academies had already been founded. So when young Augustus wished to pursue his studies further he had to cross the mountain range. A school of past and present high repute, the Burr and Burton Seminary, at Manchester, Vt., attracted him, and here with his father's approval, he entered upon college preparatory studies. In 1835 he was admitted to

Amherst College and graduated with his class in 1839. His studies were of great interest to him; mathematics, physics and the languages especially were a great delight to him. After his college graduation he went to Andover Theological Seminary, where from 1840 to 1842 he studied in preparation for the gospel ministry.

The records in the hands of the writer are too scant to permit him to speak with authority in regard to this early period of Mr. Wing's professional life; and of his ability as pastor and preacher. This, however, may be asserted: Friends, acquainted with his high attainments at Amherst and Andover, and knowing his rare mental endowments, thought him to be entering a field wide in influence and rich with the promise of usefulness. They say of his discourses, that they were logical, sympathetic, impressive and often eloquent.

But Mr. Wing's work was not to consist alone in preaching. Early in his ministry a sudden wrench, perhaps a great disappointment "where he had garnered up his heart" came to him. He stepped aside from the path that had seemed so plain, but now uncertain to him, and walked alone in another, that of teaching. Teacher and investigator he became. Not at all did he abate his interest in the studies he loved in his years of preparation. The truths of the scriptures, and the languages in which they were originally written were a source of interest to him. And so when the week day teaching was done or the week's exploration was over, he was ready to give Sunday and Bible instruction to such as were waiting for a mental and spiritual replenishment.

Academies and high schools were fortunate when they secured Mr. Wing as principal. His pupils never forgot his impressive ways of instruction. His method of teaching looked to the arousal of the highest intellectual powers of his scholars. Thought stimulated, investigation undertaken, individual judgment exercised, were in Mr. Wing's estimation of far greater value to the pupil than the acquisition of many facts from printed pages. The young people he trained never forgot their teacher. His example impressed them powerfully, and under his training they acquired an originality of investigation and an independence of thought that were of life-long value to them.

It may not be quite possible to say why a single one of the

branches of Mr. Wing's well-rounded study should have passed to the front. But the fact remains! Geology took the lead and became first the prominent then later the all absorbing topic; the constant theme of his study. Teaching itself became in a way only subservient in carrying forward his geological investigations. A generous enthusiasm came to his aid in the pursuit of his favorite research. So all available time and means were made contributors to the great object of solving self-imposed geological problems.

Geology is richer for this devotion to the advancement of the science. Vermont geology especially, has profited by taking to heart of a great unanswered question. Passing over many suggestions that readily arise as to the cause of his entrance upon this particular field we may go at once to the great subject of Mr. Wing's investigations. He himself states that in 1865 he came to the "determination to ascertain, if possible, the geological age of the limestones, slates and quartzytes of the Otter Creek valley."

A few words here regarding the field, as well as the rocks, may help to a clearer understanding of the self-imposed task.

Otter creek, better Otter river, the longest stream within Vermont, has its source in Dorset, Bennington county, flows north through the western part of the state, receives many affluents in its course through the counties of Rutland and Addison, and has its mouth at Fort Cassin, on lake Champlain in the north part of Addison county. The region studied by Mr. Wing is part of an area of the crystalline limestone of middle and western Vermont. To the south the rocks are connected with those of Massachusetts and Connecticut, while on the north they are related to those reaching up to the Canadian line. The more special field of exploration was the part of the limestone region lying between Rutland and Morriston north and south, and the adjoining region reaching westward to lake Champlain. The crystalline limestone of the Otter valley had in the Vermont geological report of Hitchcock been designated as the "Eolian limestone."

This limestone, this "Eolian," with its sandstone beneath and its slates above: what its geologic age? This was the question which Mr. Wing asked and which he set himself resolutely to answer.

The task for one of Mr. Wing's surroundings was immense. The problem was intricate and one that took years to solve. In the solution appeal must be made to the rocks themselves. It is asserted that the feet of this explorer have stood upon every square rod of exposed rock within the region of his survey. The lithological character of the rocks, their dip, their order, their fossil contents, all must be known. He carefully noted the superposition of the rocks, measured the dip with a clinometer of his own construction, and sought, with wonderfully observant eyes for traces of fossils.

The rocks of this region had been so folded, broken and worn that at first their true position was uncertain. The fossils, too, in the partly metamorphosed rocks were mostly faded and obscure; their identification difficult. But as the secret of the age of the formation must be unlocked by these fossils, this key was most carefully and in time successfully sought. Many of these fossils Mr. Wing himself determined, but for verification and in cases of doubt he turned to Mr. Billings, of the Canadian geological survey, from whom he received courteous attention and generous help.

So the search went on for years, summer and winter, holidays and vacations. Holidays gave Mr. Wing opportunity for investigating the near-by rocks, vacations afforded him time to visit far-away places in the state or in adjoining states, wherever he hoped he might get light upon his problem. It was as though he were working at a broken and tangled skein. By study of the composition of the rocks, by the use of the clinometer, but above all, by the careful comparison of fossils he disentangled the knotted, broken skein and by placing the separate threads beside each other, he arrived at a knowledge of the true relation of thread with thread; he determined the right order, the real sequence of the rocks. His problem was solved!

The problem: the age of the limestones of the Otter valley, with the associated sandstones and slates. The rocks were those designated Lower Silurian; the sandstones were the Lower and Upper Potsdam, the semi-crystalline limestone, the "Eolian" was not a single formation, but was made up of rocks of the age of the fossiliferous formations along the lake shore, now known as Beckmantown, Chazy, Black River and Trenton;

the slates were mostly the Uitca slate lying in many cases conformably above the Trenton limestone.

So the views of Mr. Wing may be fairly expressed in a few words. The limestone region of the Otter valley lies within a great syncline. On the east it is bordered essentially by ridges of quartzyte, which extend along the western foot of the Green mountains; on the west by the red sand rock whose elevation and fracture forms the great fault north and south, seven to nine miles from the Champlain shore. The axis of this syncline descends southward, while on the north it rises until the worn rims of the siliceous rocks, the quartzyte and red sand rock very nearly approach and unite. Within this trough lie the limestones and slates. These are of the age of those that lie west of the great fault, the fossils of which long ago placed them with the Lower Silurian. These strata originally deposited in regular order, by some grand mountain-making movement have been folded, compressed, snapped and displaced; the fossils by the same movement largely obliterated. The great syncline was left with subordinate north and south anticlinals and synclinals; the whole complex was exposed to the subsequent abrasions of geologic time.

It was the planing down and the enormous wastage from without, together with the great modifications of structure and position of strata within, that disguised their true character and relationship, made the order and age of the rocks such a hard problem. Time, diligence, ability were needed. And we have seen how Mr. Wing solved it. It was to him a ten-years' problem.

Mr. Wing had been slow to make known his researches, wishing apparently to put his theory beyond any possible overthrow by adverse criticism. Typical localities were re-examined that every weak point might be strengthened. He at length was clear in his own conclusions. He now wished the geological world to share with him in the results of his labors.

It was a rare day to Mr. Wing when he secured the promise from professor J. D. Dana to look into the facts, the basis of his theory. By arrangement a party consisting of professors Dana, Genth, Prime and Blake came together on July 9, 1875, at Great Barrington, Mass. A friend acquainted with the facts writes: "It was the climax in his life when Mr. Wing met

professor Dana and a party of geologists at Great Barrington, Mass., and there began to unfold his theory, verifying each position as they traveled through the Berkshire hills, and 'Hoosac valley, and made their way north, traversing the entire length of his native state, crossing and recrossing the Green mountain range, by which time his theory had given place to a deep conviction that it was correct. To Mr. Wing this, without doubt, was a moment of great triumph, when the great importance of his contribution to science was thus recognized by the highest authority in America—perhaps the highest in the world."

It is not to be asserted that all obscurities of the region, such as the relations of the lower to the upper Potsdam, the slates at the middle and southern part of the state, the exact age of the most disturbed and metamorphosed strata near the quartzyte, have been fully removed. But in the main what was to be done had been done, and Mr. Wing made good his early assertion, "That all the rocks in Addison, Rutland and Bennington counties between the great break on the west and the quartzyte on the east were Lower Silurian." The minor facts he could put over for later time, or leave indeed to others who should catch enthusiasm from the work and the success of the master.

It would have been fortunate for science if Mr. Wing could have written out his observations and discoveries. This work he fully intended to do. But he found so much in the field that, as he thought still demanded his attention, the writing was put off. He was ever finding his delight, as well as his reward, in his discoveries; so he neared his bound without having received personally the appreciative acknowledgment his fellow-workers would have gladly accorded him.

The work in the field of the season of 1875 had been severe and exhausting to him, now advancing in age, and he retired to Whiting, Vt., to accept the ministries of a sister and her family. Here this stalwart man, with large frame and great heart, with the broad intellectual range of the mature man, and yet with the simplicity of a child, of great good nature and incapable of resentment, over-flowing with enthusiasm and kindling like enthusiasm in others, came to take a needed rest.

Undiscovered truths of his loved science were beckoning him on. But there were other discoveries and other beckon-

ings. A fever set in; his peaceful death came too soon for science, for on January 19, 1876, he made the great discovery.

As before intimated there is no bibliography. And yet his line has gone out into all the recent literature of the rocks of his region. Probably a part of Mr. Wing's work has been lost beyond recall; but from field notes, letters, and incomplete papers, these latter evidently designed to be elaborated for publication, the greater part through professor James D. Dana's sympathetic labor has been recovered.

This writing gives but an inadequate idea of the real work of Mr. Wing, and so the writer most earnestly requests the reader to turn to an article in the *American Journal of Science*, Series III, Vol. xiii, page 332 and subsequent papers, that he may get a more nearly correct estimate of this work and its influence.

Fragments of significant paragraphs from professor Dana's article read:

"Mr. Wing, by the use of his spare time amid the duties of teaching, accomplished vastly more for the elucidation of the age of the Vermont rocks than had been done by the Vermont Geological Survey. * * * * Mr. Wing's discoveries shed light not on these rocks alone" (Eolian limestone and adjoining formations), "but also on the general geology of New England and eastern North America."

But the whole article and related ones should be read, for with this incomplete sketch in hand one gets but a glimpse of Mr. Wing's real work. Yet, with even this, the reader may recognize something of the obligations science is under to one who with his surroundings did his best for geology and did so well. Wherever his careful, helpful, self-denying researches are known there an appreciative recognition of Mr. Wing's contributions to science is sure to be accorded.

FIG. 1.—Concave parting in Medina sandstone, Slack's quarry, Holly, N. Y., Looking W. 10° N.

FIG. 2.—Succession of four convex partings or ridges in Medina sandstone, Old Quarry, Albion, N. Y. Looking S. W.

FIG. 3.—Concave partings in Medina sandstone, Horan's quarry, Medina, N. Y. Looking S. E.

"BEACH STRUCTURES IN MEDINA SANDSTONE."—H. L. FAIRCHILD.

FIG. 4.—Concave parting in Medina sandstone. Squire's quarry, Hulberton, N. Y. Looking S. E.

FIG. 5.—Crested ridge in Medina sandstone. McCormick's quarry, Medina, N. Y. Looking S. 15° E. (The sharp line of the ridge crest is not properly shown.)

FIG. 6.—Concavity in Medina sandstone. Whitmore quarry. Lockport, N. Y. Looking N. 20° E.

"BEACH STRUCTURES IN MEDINA SANDSTONE."—H. L. FAIRCHILD.

FIG. 7. Concavity and ridge in Medina sandstone. Lockport, N. Y. Looking N. W.

FIG. 8.—Ridge in Medina sandstone. Lockport, N. Y. Same as in Fig. 7.

FIG. 9.—Ordinary ripples on the summit of the ridge shown in Figs. 7 and 8. The arrows in Figs. 7 and 8 point to the ripples.

"BEACH STRUCTURES IN MEDINA SANDSTONE."—H. L. FAIRCHILD.

FIG. 10. Crested sand ridge on the beach of Lake Ontario. Looking W.

FIG. 11.—The same sand ridge as shown in Fig. 10, but the view taken a day later. The stakes mark the crestline of the previous day. The crest is now at the end of the clinometer, and not distinct in the engravings.

FIG. 12. The same sand ridge as shown in Figs. 10 and 11, but looking eastward at the west end.

"BEACH STRUCTURES IN MEDINA SANDSTONE."—H. L. FAIRCHILD.

FIG. 13. Five parallel ridges in Medina sandstone. Gwynne's quarry, Murray, N. Y. Looking N. The ridges show poorly in the view on the floor of the quarry.

FIG. 14. Basin in Medina sandstone. Looking N. W. Near the ridges shown in Fig. 13.

FIG. 15. Basin between sand ridges, beach of Lake Ontario.

"BEACH STRUCTURES IN MEDINA SANDSTONE."—H. L. FAIRCHILD.

BEACH STRUCTURE IN MEDINA SANDSTONE.

H. L. FAIRCHILD, Rochester, N. Y.

PLATES II-VI.

Since Dr. James Hall published, nearly sixty years ago, his "Geology of the Fourth District," the Medina sandstones of western New York have been regarded as shallow-water deposits. On pages 34 to 57 of that remarkable work he describes the markings which occur in great profusion in the sandrock and compares them with the features that he had studied on the living beach of Ontario. It is a fine example of inductive reasoning, and seemed to determine past all question the shoal-water genesis of the Medina sands. While the lower strata and the clayey beds were thought to indicate relatively deeper water, the quartzose bed, as at Lockport and Medina, were "evidences of a sandy beach which was alternately washed by the advancing and retiring waves and again left dry and above their reach."

Subsequent workers on the Medina have followed Dr. Hall's conclusions, apparently without question, until a recent paper by Dr. Gilbert, which interprets certain curving and crested structures in the sandstone as "giant ripples" formed in deep ocean.*

In examination of the Medina sandrock in numerous exposures and quarries between Rochester and Lockport the writer has found no reason for questioning its origin as beach sands, and believes that the ridges and hollows in question are typical beach structures. In this paper it is proposed to briefly state the facts and argument.

Character of the Sand Rock.

The red Medina of western New York, 1075 feet thick at Rochester, is mostly an arenaceous shale and unfit for building material. In the upper horizon, and lying at the surface in the region of Brockport, Holly, Albion, Medina, and Lockport, are thick lenses of nearly pure sandstone, in great demand for paving and buildings. Very thin laminæ of clay occur in the seams of the sandrock, particularly in the concave partings. Locally the clay may constitute definite beds or may alternate with the sand layers. The particular point is that the sand-

* "Ripple Marks and Cross-bedding," *Bull. Geol. Soc. Amer.*, 10-135.

rock is typical beach sand and not deep-water material. This seems evident from the size and shape of the grains, and from the absence of the finer product of trituration in the sand layers. The material is too coarse to be swept far off into deep water.

Abrupt Changes of Material.

In some sections there are frequent and sudden changes from clear sand to fine clay, as mentioned above, see figure 6, plate —. Such abrupt changes do not seem possible in deep off-shore waters, but are characteristic of shore deposits.

Oblique Bedding.

This is a very common and characteristic structure of the sandrock, so common indeed that it spoils a large part of the quarry product, and in many openings entirely prevents profitable working. Figure 1, plate II, shows a fair example. The old Whitmore quarry, at Lockport, was not worked below, a certain plane on account of this structure.

Ripples, Wavelines Etc.

These minor structures, the most common and convincing proof of wave work, are exceedingly abundant. No one can see the older sidewalks of western New York towns without being impressed with the beach origin of the flagging. Wave-lines are frequent in great perfection on the smoother flags, while ripples are so common and so regular that the quarrymen call them "washboards." Other features, as rill-marks, wind effect, transported shells, etc., are also common.

Ridges and Troughs.

A frequent structure, and the one which suggested the idea of "giant ripples," are curving seams, sometimes forming hollows or upward-facing concavities, sometimes making flat arches, and rarely forming crested ridges with slightly concave sides. Examples of these structures are shown in figures 1 to 8 and 13, plates II, III, IV, V. To the writer there seems no reasonable doubt that these structures were produced in the process of deposition of the sand. They are not induced or secondary features but structural. Thin laminæ of clayey material often make the separating planes.

The most interesting and significant of these structures are the sharp-crested ones. Examples are shown in figures 2, 5 and 8, plates II, III, IV. Figure 5 shows the one which gave to the writer the clue to their origin. The photograph does not properly show the clean, sharp, straight crestline. Nor does it show what was at first a surprise and puzzle, the clear, unmistakable wavelines that swing across the crest in varying curves. The overwash of the waves seemed inconsistent with the preservation of the sharp crestline. But this made necessary the study of the living beach, with the result that precisely similar structures were found upon the beach of lake Ontario; and the process of their construction was studied.

Figures 10-12 and 15, plates V, VI, are from photographs of such ridges on the Ontario beach at Sea Breeze, near the outlet of Irondequoit lake. Figure 10 was taken late one afternoon while the lively waves and currents were building the ridge. Figures 11 and 12 show the same ridge the next morning when the formative process had ceased. This ridge was built on the flank of a larger ridge formed a few days previous by a windstorm of greater force. Between the two ridges is a decided trough, into which in this case has been thrown the wreckage of water plants. The ridge and hollow would on cross-section illustrate those formed millions of years ago on the sand beaches of the Medina sea. This trough had a breadth of perhaps ten feet, but others formed the same day along the same shore were twenty and thirty feet wide. The breadth of the trough is, however, of little significance as the trough is only a negative or passive element and depends upon the accident of location of the second ridge with reference to the earlier ridge. The width of the same trough is also very variable. On the sea shore, with changing level of tidal waters, the ridges might sometimes lie far apart.

In figure 10 we are looking along the crested ridge in the direction of its growth as a spit. Before leaving the beach, late in the afternoon, several stakes were set at intervals exactly in the crestline. At the end of the growing spit a black post was set on the center line and at the height estimated as the average waterlevel. This post appears in figure 12. The following morning another visit was made to the place and

other photographs taken, of which two are reproduced in figures 11 and 12. The poor lighting in the last two views does not properly show the crestline, which was really as clear and definite as when figure 10 was taken. In figure 11 the crestline is at the higher end of the instrument (a folding clinometer, one foot long) lying on the sand. This view shows that the later effect of the waves on the older part of the ridge was to shift the crestline landward a few inches, the stakes showing its earlier position. Figure 12, facing the opposite direction, shows how the spit had lengthened to a crested ridge, before the subsiding waves entirely ceased their action.

The mechanics of the ridge-building involves some undetermined factors but the general process is evident. The seaward face of the ridge has the variable curve and angle produced by the glide and push of the tongues of water from the broken waves. Along the line reached by the greater number of tongues of water there is built up an irregular, sinuous crest of sand which the water pushes up on its forceful advance and leaves there as it softly retires or sinks into the thirsty sand. This line is often darkened by magnetite and garnet concentrated there, which suggests that there is a tendency to leave the heavier grains at the crest. The few stronger tongues of water which push clear over the crest do not destroy or break down or obliterate the crestline but do smooth it and straighten it into a clean, sharp line, the summit of a low angle. This line is usually as direct as the embankment of which it forms the crest. Sometimes it may be apparently straight for several rods, but really makes curves of large radius.

The dimensions of these crested ridges on the Ontario shore were not accurately measured. They differ greatly in size, varying from a few inches to a few feet in height, and from a few feet to a score of feet wide at the base; with a length sometimes of a few hundred feet. It would seem that with the greater bouyancy of sea water and the greater force of sea waves similar structures on the sea beach would often attain greater size, and the intervening troughs be correspondingly broader. However, some of these structures seen on the Ontario shore are comparable in dimensions as well as form with those found in the Medina sands.

At points where shoreline topography or streams produce diversion or conflict of currents the embankments may lie in different directions and may even enclose basins. Figure 15, plate VI, show such a basin at the outlet of Irondequoit, and figure 14 shows a similar basin in the Medina, where basining dip is not infrequent.

Argument against "giant ripples."

1. For troughs 30 feet across Mr. Gilbert suggests waves of the Medina sea 60 feet high. But the highest waves of the Atlantic are, according to Scoresby, only 43 feet high. On the other hand, the writer has seen troughs in the Medina sandrock up to even 80 feet across.

2. If these ridges were deep-water ripples then we should expect to find ripples of all lesser sizes down to the common form. Can any geologist report true ripples broader than three or four inches?

3. If these ridge-and-trough structures were deep-water phenomena then they should be common features in all deeper water deposits, as shales and limestones. Figure 6, plate III, shows a section in the old Whitmore quarry, north of Lockport. The absence of curving structure in the shale is apparent, while a large concavity, 40 feet across, lies in the heavy bottom stratum of sandrock. This sand stratum is the same horizon as the one containing Mr. Gilbert's ridges, shown in figures 7, 8 and 9, and is about 60 rods westward.

As "giant ripples" these ridges should occur in series or succession of uniform direction, hight and spacing. On the contrary they are usually isolated and single and in the same quarry lie in different directions. The nearest approach to a series of crested ridges that has been found is shown in figure 2, plate II. It will be seen that the ridges in this view are of diminishing size toward the right, while the larger ones at the left are rounded and without crests. These characters agree precisely with those found on the modern beach. It is only a series of diminishing size that can be formed, since a stronger storm necessary to make the larger ridge would cause the waves to override the previous smaller ridges and destroy them. The older ridge, exposed to the air and drying, soon loses its crest, if it had one, and assumes the rounded form seen in figure 2, plate II, and in figure 10, plate V.

5. The thin clay partings which occur in the seams of the hollows are inconsistent with uniform deep water conditions, but are more easily explained as beach phenomena. The muddy water often left in a trough after the storm will drop its finer material, which was held in suspension, and so produce the clayey layer.

6. The crests of the ridges are sometimes truncated, which suggests erosion of previous deposits, and implies shallow water.

7. The surfaces of the ridges sometimes bear the common small ripples, one to three inches across. Figure 9, plate IV, shows such small ripples over the crest of the ridge shown in figures 7 and 8. (The arrows placed on figures 7 and 8 point out the location of the ripples.) Their size may be estimated from the foot-rule lying beside them. The lower seams of the ridge also bear suggestion of fine rippling.

8. The ridges sometimes preserve the marks of the waves that softly glided up or over them. As described above, wavelines showed clearly on the ridge photographed for figure 5, but are not brought out in the view. Wavelines are quite unmistakable features and their presence would seem to make the conclusion unavoidable that the deposits which hold them are beach deposits.

THE MICHIPICOTEN HURONIAN AREA.

A. B. WILLMOTT, Sault Ste Marie, Ont.

On the northeast shore of lake Superior is a tract of about 5,000 square miles known as the "Michipicoten Mining Division." Originally set apart because of the discovery of gold-bearing quartz, it now promises to become of more importance by reason of its iron beds. The tracing of the iron belt during the past summer has given some better idea of the geological structure than was previously known.

The oldest rocks of the district are the greenstone schists. Some of these are undoubted lava flows, showing the characteristic elliptical structure described by Clements,* as occurring in the Crystal Falls Hemlock formation. At a number of points agglomerates are found, as at Little Gros Cap fish sta-

*Mon. xxxvi, *U. S. Geol. Sur.* 112-124.

tion, north of Goetz lake, east of Manitowick, and elsewhere. Commoner occurrences are the various green schists, chlorite, hornblende, mica and sericite schists. Presumably all these schists are derived from lavas, basic and acidic. The dip of the schists is always nearly vertical and the strike follows closely the line of contact with the granite to be described later.

Succeeding these schists, perhaps interbedded with them, are the earliest sediments of the region. The most characteristic of these is a belt of ferruginous chert, which has been found at intervals for about sixty miles. This rock consists of banded hematite and silica with usually some residual carbonate of iron. The bands vary from one-tenth of an inch in thickness up to several inches. The silica is sometimes very like loaf-sugar; again it is like quartzyte, a chert, or a jasper. Red jasper is, however, not infrequent. The hill at the back of the Helen mine is a huge mass of siliceous carbonates. The rocks as a whole, and the mode of occurrence of the ore, are strikingly like the Lower Huronian iron formations of Marquette and Tower.

Besides the iron formation, beds of carbonaceous shales and limestones have been recognized at several points. Shale occurs interstratified with the ferruginous chert at Iron lake. Near Paint creek and at Eleanor lake it has also been found. Whether it always underlies the iron formation is undetermined, but it probably does not. The cherty limestone has been traced in a fairly continuous line from the Helen mine to the east of Parks lake, a distance of twelve miles.

Overlying these sediments is a very persistent belt of schist conglomerate. It is well exposed at the mouth of the Doré, where it was studied by Sir William Logan and described by him in the Geology of Canada*. Coleman† describes the boulders as "granites most frequently, then quartzytes or sandstones with pebbles generally small, next green schists, then felsyte schists and porphyroids, and finally a few gneisses, but none of the Laurentian type." A thin section of one of the quartzyte pebbles showed considerable carbonate, proving that it undoubtedly came from the iron formation.

This conglomerate has been traced pretty continuously for thirty-eight miles in a semicircular belt around the central

*Geol. of Can. 1863, pp. 53-4.
†Bur. of Mines. Ont. 1889, viii, pp. 164-7.

granite boss. At many points, as at Iron lake, Dog river, Doré river, Wawa lake, it contains pebbles from the very characteristic iron formation which fixes its age as Upper Huronian.

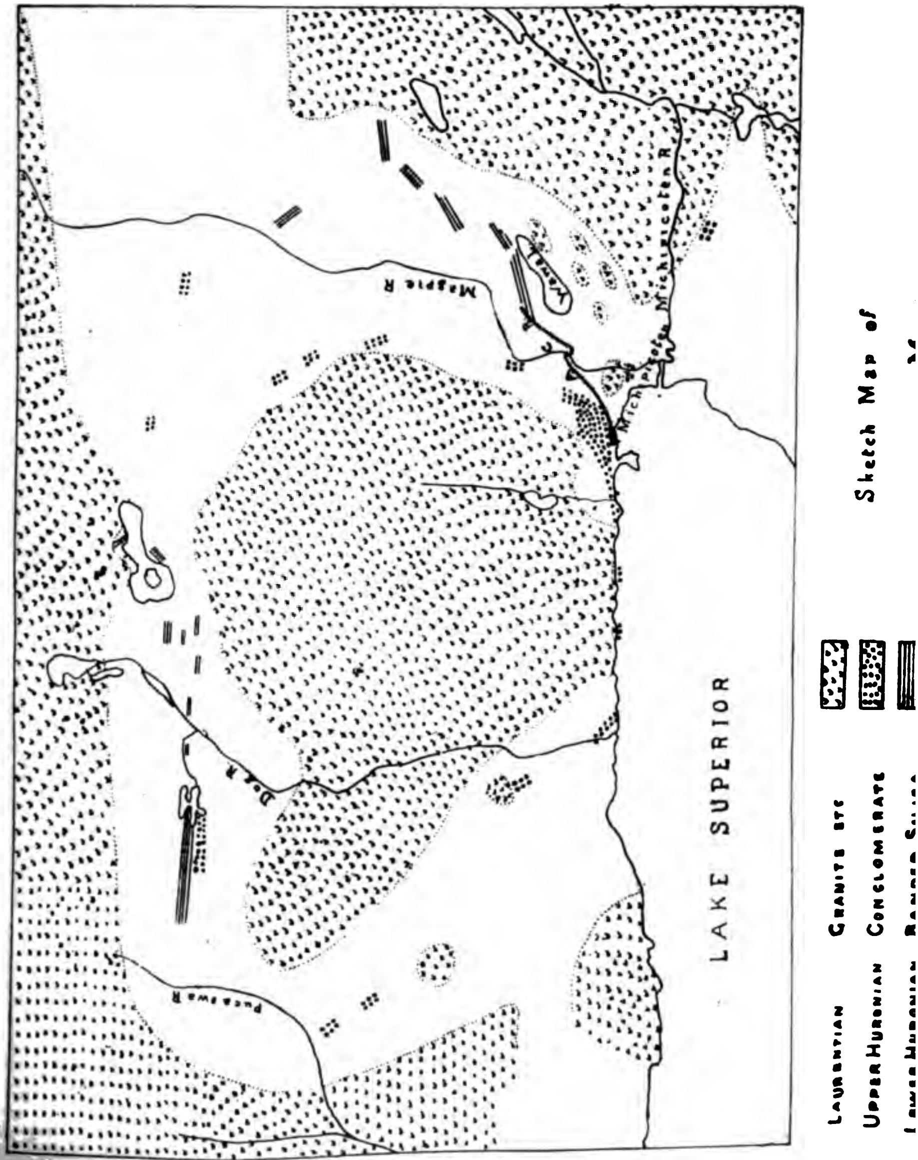
Within this conglomerate belt is a roughly oval area of granitoid gneiss, nineteen miles by twenty-eight. This has always been mapped as Laurentian because of the striking lithological resemblance to the Ottawa gneiss. However, it is in undoubted eruptive relations with the conglomerate along the shore of Superior,* for example a few miles west of the Doré. A mile and a half up the Magpie, a boss of granite is in eruptive contact with the conglomerate, and although it may not be of the same age as the larger boss three miles to the northwest, it probably is. In the opposite direction a succession of granite-gneiss bosses intrusive in the schists are found, for six miles, after which the granitoid gneiss occurs without interruption for over a hundred miles.

North of the mouth of Dog river and along Catfish creek search along the contact will probably show it to be an eruptive one. Nowhere has the granite gneiss been found in actual contact with the iron formation, but no search was made for it. It might be found on the north shore of Kabenung lake. On Paint lake an intrusive granite-gneiss boss cuts the iron formation, and this is very probably of the same age as the similar eruptive rocks, two miles to the north and three to the south.

The contacts of the granite gneiss with the green schists are much more numerous and in all cases the schists are the older. Eruptive in all the foregoing are numerous dikes of diabase which seem to be of Keweenawan age. Other dikes, restricted to the green schists, are of course older.

If the facts here given are correct, the geological succession is different on the north shore of Superior from that determined on the south. There the larger areas of granite etc. are placed in the basement complex, later than the green schists but earlier than the lowest iron-bearing formation. Here a large area of granite-gneiss, nineteen miles by twenty-eight, is in eruptive contact with a conglomerate carrying very characteristic pebbles of the Lower Huronian formation. Is this area of the same age as those usually designated Laurentian in Canada? I think so, and for these reasons:—

*See also Coleman, *Bur. of Mines, Ontario*, viii, p. 166.


Magpie R
Michipicoten R
Dog R
Pucaswa R
LAKE SUPERIOR
Laurentian
Granite etc
Upper Huronian
Conglomerate
Sketch Map of

(1) Southeast of the Michipicoten river and reaching within nine miles of this area is an unbroken mass of granite-gneiss which extends 120 miles southeast to the original Huronian. If there is any Laurentian in the country, this must represent part of it. This Laurentian area extends six miles farther northwest in broken contact with the green schists. Three miles farther the area under discussion bears a similar relation to the same schists, though between there lies the trough filled with Lower and Upper Huronian sediments.

(2) The two areas are alike lithologically, and might well be of the same age.

(3) The large southern area is in eruptive contact with a conglomerate south of Michipicoten falls. This conglomerate has not been studied, and its age is unknown, but it cannot be earlier than Lower Huronian and is more likely Upper Huronian, as no Lower Huronian conglomerates have yet been recognized in the district. Accordingly, this Laurentian is at least post-Lower Huronian, if not later, which makes the equivalency in age of the two areas at least probable.

It will be urged that if all the granite-gneiss of the region is post-Upper Huronian there is no floor on which the early volcanic flows could be laid down. Possibly Lawson's suggestion regarding the Rainy Lake district applies here also. In both regions are masses of green schists almost vertical, surrounding a batholith of granite in eruptive contact with them. Lawson held that if the granite was the original crust on which the volcanics had been deposited, it had afterwards been refused.

At the Doré the pebbles of granite were probably derived from a mass now beneath the waters of Superior. Not only do they differ from the known exposures of granite to the north, but the cherty pebbles certainly came from a belt on the south, only a few hundred feet of which is now visible on the peninsula of Gros Cap. The way in which the conglomerate encircles the granite suggests that originally this central area was a water basin. The conglomerates surrounded the shores, and doubtless finer sediments occupied the center of the depression. The granite mass was then upheaved, and the schistosity produced in the lavas and sediments through which it extruded. In places it is now found in contact with the Upper

Huronian conglomerates; in others with the underlying green schists.

Similar relations seem to hold in the original Huronian area. Murray's Lower Slate conglomerate is just such a rock as that at the Doré. It contains at nearly all points at least a few pebbles of chert or jasper derived from some earlier sediment. Coleman* mentions such pebbles as being found in the so-called basal conglomerate at Thessalon. I have myself found very numerous and quite large pebbles (up to six inches diameter) of banded jasper, in both the Lower and Upper Slate conglomerate, forty miles up the Mississaga. Where the contact occurs between the Laurentian gneiss on the north and the Lower Slate conglomerate, pebbles of jasper are also found, but not very abundantly. On the Mississaga the actual contact of the conglomerate and granite-gneiss seems to be an eruptive one. Murray's map† shows a fault along the contact line by which he no doubt thought to explain the later consolidation of the granite-gneiss. His only printed statement is as follows:‡ "The northern shore of the lake, and the mountains north from it, appear to be composed of granite and syenite; in both of which there is occasionally observable an obscure gneissoid structure, giving them the aspect of gneisses, so that here as in the valley of the Spanish river (page 1) it is very difficult to say whether they are intrusive or altered rocks."

Again, in describing a contact twelve miles east of Thessalon, Murray writes:§ "At the southeast end of lake Pakowagaming (Mud lake) there are red quartzytes, slates, and other rocks of the Huronian age, whose place in the series is yet uncertain, but they are all twisted, highly tilted northward or vertical, and on the southwest side of the lake for two miles up in the bights of the bays and in positions behind the greenstone points and promontories, there are exposures of well characterized massive gneiss * * * [This] makes it very probable that we have here an exhibition of a portion of the Laurentian series, brought up against the Huronian from a great depth." On the accompanyng atlas a fault line is shown for twenty-five miles where the formations come together. My own observations last summer on lake Pakowa-

*Bur. of Mines, Ontario, viii, p. 162.
†Geol. of Can., 1863, Atlas.
‡Geol. of Can., 1863, p. 842.
§Rep. Geol. Sur. Can., 1858, p. 95.

gaming, while indecisive because of poor exposures at the critical points, confirm Murray's conclusions. Only I would explain the facts by the later consolidation of the eruptive granite-gneiss—not by a fault.

Several geologists have divided the original Huronian in two, making the break either above or below Murray's limestone band (*e*). While it is true that occasional pebbles of the limestone occur in the Upper Slate conglomerate I do not think the break is at all an important one. It is what Van Hise himself has described* as an intraformational conglomerate to be carefully distinguished from a true basal conglomerate. The two slate conglomerates of Murray are so much alike that they cannot be distinguished. Where the limestone band is absent, as it often is, they join, and Murray himself† confesses that he could not draw the dividing line. The real break, I am convinced lies at the base of the Lower Slate conglomerate and associated quartzytes. The Huronian of lake Huron is thus nearly all Upper Huronian. Logan's Huronian at Michipicoten included, however, a lower formation, characterized by its banded jasper and iron.

The succession of Michipicoten would thus be:

Keweenawan, volcanics and sediments,

Laurentian, eruptives,

Upper Huronian,

Lower Huronian, volcanics and sediments.

In this arrangement, I know that I am ignoring the conclusions founded on a supposed basal conglomerate at Thessalon described by Pumpelly and Van Hise.‡ The evidence here does not seem to be very decisive, since Barlow § interprets it in an opposite manner and after a recent examination I incline to his view. Moreover, if true it is almost an isolated case against which scores of observations have been made pointing to the eruptive character of the granite-gneiss. The conclusions of Barlow‖ in the district extending from the Mississaga to the Ottawa, seem to apply equally as well to the region from the Mississaga to the Michipicoten and beyond.

May 30, 1901.

**Prin. Pre-Camb. Geol.*, p. 723.
†*Rep. Geol. Sur.* 1858, p. 94.
‡*Am. Jour. Sci.* 1892, xliii, pp. 224-232.
§*Geol. Sur. Can.* x, 1897, p. 93, I and references.
‖Ib. pp. 59, 60, 92. I.

THE AGE OF THE KANSAN DRIFT SHEET.

By OSCAR H. HERSHEY, Berkeley, California.

Although somewhat belated and subject to the generalizing effect of impressions dimmed by time and the vicissitudes of rough life in a mining camp, I desire to add my quota in support of the proposition that the Kansan drift sheet of the Mississippi basin is a very old one. For some years I have been in the ranks of those who maintain that the earlier glaciations of the Upper Mississippi region occurred long prior to the last or Wisconsin, but it is only recently that I have come to appreciate the significance of the evidence.

The "earlier drift" of northwestern Illinois is manifestly so much older than the Iowan drift, that it was for some years correlated with the Kansan sheet of southern Iowa, Missouri and Kansas. Being surrounded by impressive evidences of the aged condition of the former, I was somewhat skeptical of the existence anywhere in the Mississippi basin of a drift sheet which could be proven to be of yet greater age than it and was not inclined to approve suggestions that the old drift of northwestern Illinois was more recent than the Kansan and probably a portion of the then lately discriminated Illinoian sheet.

In the summer of 1899, while on a pedestrian trip from Freeport, in Illinois, to Mena, in Arkansas, I took occasion to visit Mr. F. Leverett at his home in Lee county, Iowa, and he conducted me across the broad smooth ridge which bounds the Illinoian drift and on to the Kansan area to the west. It was in this region, I believe, that Chamberlin first recognized the significant difference in topography of the two sheets now known respectively as Illinoian and Kansan, and his interpretation has been ably supplemented by the investigations of Leverett, as well as by detailed investigations by the Iowa Geological Survey.* My conversion to their opinion was rapid and complete. Subsequently this was re-enforced by observations in northeastern Missouri where the Kansan drift sheet and its attendant erosion topography are typically developed.

*A fuller discussion of this subject is contained in Mr. Leverett's report on the "Illinois Glacial Lobe," forming Monograph XXXVIII of the U. S. Geol. Survey.

The Kansan ice sheet left the territory of northeastern Missouri as a remarkably even plain sloping gently toward the southeast. The pre-Kansan erosion topography was completely obscured, the valleys having been filled with drift (mainly till) to a hight greater than the rock ridges, so that the present drainage lines do not conform to the courses of preglacial streams. There were apparently no moraines or eskers to interrupt the evenness of the plain. Although this original drift plain has been mainly destroyed by subsequent sub-aerial erosion, by looking across the summits of the main divides its outline may be distinctly seen. As in the case of a dissected peneplain, in the far distance the valleys disappear from view and the country has the appearance of yet remaining undissected. It seems impossible to account for the fact that the crests of the main ridges of drift all fall into a single plane as the accidental result of the deposition of drift.

Now, the Kansan plain of northeastern Missouri has been very completely dissected. The drainage basins are long and narrow, but the valleys are dendritic in character and the topography typically that of erosion. The main valleys have been trenched to a depth of 100 to 150 feet and have broad, flat bottoms, one-fourth, one-half or not infrequently an entire mile in width. They are joined at frequent intervals by tributary valleys, the ridges between which have been reduced much below the original plain level. In fact, it is only along a few of the main divides, as that followed by the Santa Fé railroad between LaPlata and Moberly that the original plain remains practically undissected for a width of as much as one mile. It is the general degradation of the upland which is the most striking feature of post-Kansan erosion.

Railroads in crossing this area transverse to the main streams, as does the Santa Fé between LaPlata and the Des Moines river, only reach the level of the original plain at rare intervals. For three, five, or in places ten miles, in passing from one main divide across a basin to another high ridge, they are much below the level of the upland. Probably one-half of the material between the level of the main valley bottoms and the original plain, a vertical interval in some sections of 150 feet, has been removed by erosion. In short, in terms of the geomorphologists, the topography may be said to be com-

paratively old, for the valleys occupy a large part of the surface, are of the basin tyne, and most of the ridges have been reduced much below the original level.

Where the Illinoian ice sheet left the surface as a gently-sloping till plain as in western Illinois and southeastern Iowa, we find a distinctly different type of topography. Valleys are fairly numerous and in places 100 or 200 feet deep, but they are of the cañon type rather than of the basin tyne so characteristic of the Kansan areas. Much of the surface has been reduced but little below its original plain level and the railroads in crossing Illinoian areas transverse to the main drainage lines are most of the time on the plain so that the passenger may leisurely study the upland country while on the Kansan areas, as already mentioned, he catches but a fleeting glimpse of the old plain level as the train crosses a main divide. Surely this difference means something. Probably of the total amount of the Illinoian drift between the level of the main valley bottoms and the original plain there has been removed by erosion no more than one-tenth or at most one-fifth.

Where the Illinoian and Kansan areas adjoin as in Lee county, Iowa, the contrast in topography is great. The very thoroughly dissected and much eroded Kansan drift is overlooked by a broad ridge of Illinoian drift, whose comparatively steep slopes, if exposed to erosion as long as has been the former district, should be deeply trenched by valleys; indeed, the moraine should be nearly destroyed. For about one mile, just outside or west of the moraine, the Kansan erosion topography is mostly obscured, being buried under a sheet of silty material of Illinoian age. It is here evident that the Kansan area had largely received its present old erosion topography before the Illinoian drift was deposited on it.

In southeastern Iowa the streams in the Kansan area did not cut down to so great depth as in Missouri, the larger pre-Illinoian valleys apparently having had a depth of only 50 or 60 feet, though they had a width of one or two miles. On page 106 of his admirable monograph on the "Illinois Glacial Lobe," Mr. Leverett says: "In the district occupied by the Kansan the erosion is so great that only narrow remnants of the original drift plain are preserved, along the water partings. But in the district occupied by the Illinoian more than half of the

original drift plain is preserved, and that, too, on the immediate borders of the Mississippi where conditions for erosion are more favorable than in the area to the west which is occupied by the eroded Kansan sheet. The great contrast in amount of erosion supports strongly the view that a longer interval elapsed between the Kansan and Illinoian glaciations than between the Illinoian and the present time." To one who has given any attention to erosion studies in the district referred to the above conclusion appears quite conservative.

In situations such as these old drift plains, the Wisconsin drift sheet has suffered practically no erosion, and the Iowan also very little. These two sheets are, therefore, very, very recent as compared with the older. In northwestern Illinois where the country was hilly after the deposition of the drift, there is abundant evidence that the Illinoian or earlier sheet is much older than the Iowan, but if it were so old as the Kansan it must have been almost completely destroyed by erosion. The eskers show great erosion, yet if of Kansan age they should be reduced to low rounded mounds instead of the sharp peaks which they present. I think as a result of these comparative studies that there can be little doubt of the *Illinoian* age of the drift in northwestern Illinois formerly known as *Kansan.*

There is another phase of the subject to which I wish to call attention as it is a matter which I believe has not yet been discussed by anyone: As the evidence shows that the Kansan drift sheet is very much older than the Illinoian and later sheets, it may be suspected that it is even of greater age than the Quaternary era as the term is usually understood. The erosion effected on the Kansan drift plain is as great as many have been willing to credit as the capability of the entire Quaternary era.

In passing off of the Kansan drift on to the unglaciated area of southern Missouri, I was surprised to find that the type of the erosion topography did not materially change. Where the tilting of the original plain surface was slight and the streams did not cut down deeper than in northern Missouri, the valleys had the same shape and about the same amount of the plain remained. In the vicinity of Tipton, along the main divide between the Missouri and Osage rivers, there is a flat plain of

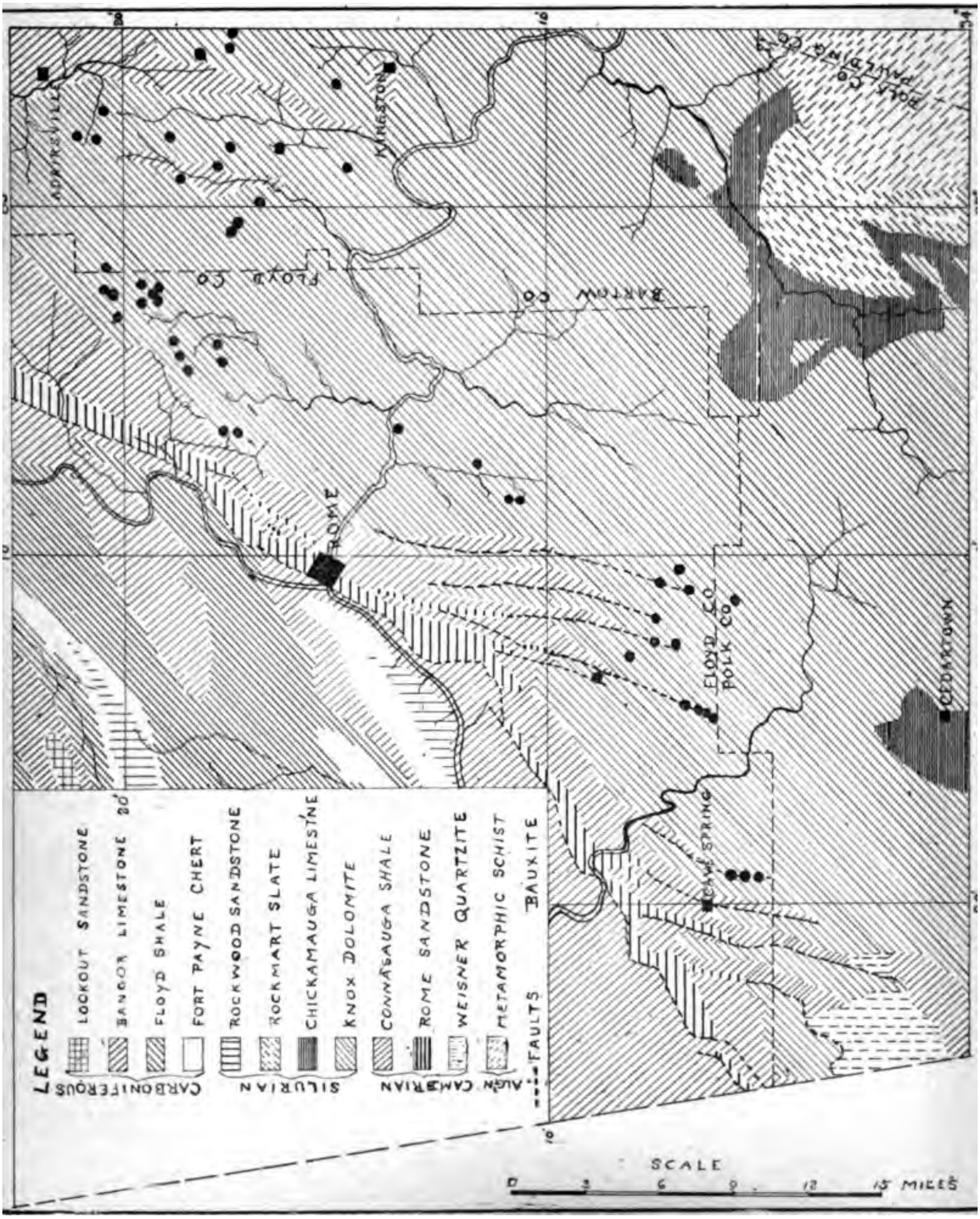
greater width than that at Moberly in northern Missouri. It is bounded on either hand by more deeply trenched valleys than those in the neighborhood of the Moberly plain.

In general, I should say that under like conditions as to stream gradient, the valleys of southern Missouri are about twice as large as those of northern Missouri. Of course, the Ozark region has been abnormally uplifted and in a large portion of it erosion trenches are much deeper than in any part of northern Missouri, but where conditions have been essentially alike (except for material eroded) there is far from as great difference in excavation accomplished as we should expect except under our previous conceptions of the age of the Kansan drift sheet.

If we compare the valleys of northern Missouri with that portion only of the valleys south of the Missouri river which is below the supposed Lafayette base level,* it will appear that there is scarcely any difference in the amount of material removed by streams of an equal size and an equal gradient; if there is any difference it is in favor of the post-Kansan valleys of the drift area. However, we must remember that the valleys of one region are carved almost exclusively in drift and in the other in solid rock. There are many places in the glaciated area where the difference in power of resistance to erosion of ordinary till and such rock as commonly occurs in the Mississippi basin may be observed. The ratio is not less than as 1:5. It is therefore certain that the valleys of northern Missouri have not been exposed to erosion as long as the post-Lafayette valleys of southern Missouri, and we have no reason for carrying the age of the Kansan drift back into the Tertiary era. Indeed, from the relation along the boundary of the glaciated area of the drift sheet and valleys in solid rock, it appears that the latter had been eroded to largely their present extent before the Kansan epoch. There are not yet known any clear cases where this may be studied, but it is known that the rock surface under the drift of northern Missouri is very uneven and contains valleys such as the Ozarkian valleys of southern Missouri.

I have detected what I consider evidences in the Kansan area near Higginsville, about 30 miles north of the Missouri

*"Peneplains of the Ozark Highland," *Am. Geol., Jan., 1901.*


LEGEND
CARBONIFEROUS
LOOKOUT SANDSTONE
BANGOR LIMESTONE
FLOYD SHALE
FORT PAYNE CHERT
SILURIAN
ROCKWOOD SANDSTONE
ROCKMART SLATE
CHICKAMAUGA LIMESTNE
CAMBRIAN
KNOX DOLOMITE
CONNASAUGA SHALE
ROME SANDSTONE
WEISNER QUARTZITE
ALGN
METAMORPHIC SCHIST
FAULTS
BAUXITE
ADAIRSVILLE
KINGSTON
FLOYD CO
BARTOW CO
POLK CO
PAULDING CO
ROME
FLOYD CO
POLK CO
CAVE SPRING
CEDARTOWN
SCALE
0 3 6 9 12 15 MILES

river, of remnants of the Lafayette formation under the drift. If the identification prove correct, the Kansan drift will thus be demonstrated to be newer than the Lafayette formation. True, it has by many glacialists been so considered for years, but it is hardly proven. The evidence drawn from the valleys as given above is as yet the strongest which can be adduced.

My present impression is that between the close of the Lafayette epoch and opening of the Kansan glaciation of the Missouri region, the cañon valleys of southern Missouri had been eroded to nearly their present size and that while the great post-Kansan denudation was being accomplished on the drift plain at the north, erosion south of the Missouri river was confined chiefly to a widening of the cañon valleys which, while relatively small as measured in material removed, was yet large as measured in time occupied.

In conclusion, I submit the proposition that while the Kansan epoch is probably post-Tertiary in taxonomic position, recent erosion studies on the Kansan drift areas cut sadly into that supposed long preglacial portion of the Quaternary era designated the "Ozarkian sub-period" and when the still earlier drift sheets have been correctly placed in the time scale, there may be little left of it.

Berkeley, Cal., Feb. 2, 1901.

THE GEORGIA BAUXITE DEPOSITS; THEIR CHEMICAL CONSTITUTION AND GENESIS.*

By THOMAS LEONARD WATSON, Geol. Survey of Georgia, Atlanta.

PLATE VII.

Introduction: As the heading implies, the object of this paper is to explain the chemical constitution and genesis of the bauxite deposits of the Coosa valley region of Georgia and Alabama. The discovery of bauxite in 1887,† a few miles northeast of Rome in Floyd county, Georgia, was the first account of this mineral found in the United States. The first shipments of the ore were made in 1888, and the entire home consumption of bauxite in the United States has been, since 1890, from the Coosa valley deposits in Georgia and Alabama. Although commercial deposits of the ore have been known in

*Published by permission of the State Geologist.

†NICHOLS, EDWARD, An Aluminum Ore, *Trans. Amer. Inst. Min. Eng.*, 1887, vol. xvi, p. 105.

Arkansas since 1891,* practically no shipments have yet been made, though active preparations are now under way for a large output in the near future. The mode of occurrence and genesis of the deposits in the Georgia-Alabama and Arkansas districts are entirely different.†

The Georgia-Alabama deposits have been studied in considerable detail by Spencer,‡ Hayes,‖ and McCalley,§ and theories to explain their origin have been independently advanced by Spencer and Hayes, which differ greatly from each other. While the writer's views concerning the Georgia-Alabama bauxite region are essentially the same as those stated by Dr. Hayes, the data and conclusions in this paper are based primarily on a detailed field study of the same region during 1899.

Since the physical conditions of the bauxite, including form and mode of occurrence, and the intimate relationship in the distribution of the deposits to the structural features of the region are important factors, which bear directly on the genesis of the ore bodies, it is necessary to first briefly review the general geological conditions of the area, embracing a general description of the ore and its manner of occurrence.

RÉSUMÉ OF THE GEOLOGY OF THE BAUXITE AREA.

The distribution of the ore-bodies is shown on the accompanying map (Plate VII.) As there shown, the deposits are found within a narrow belt of country, extending from Adairsville, Georgia, southwestward into Alabama. A few scattered deposits occur outside the limits of this belt near Calhoun in Gordon county, and in the vicinity of Summerville in Chattoo-

*BRANNER, JOHN C., Bauxite in Arkansas, *American Geologist*, 1891, vol. vii, pp. 181-183.
Ibid, The Bauxite Deposits of Arkansas, *Jour. Geol.*, 1897, vol. v.
WILLIAMS, J. FRANCIS, Igneous Rocks of Arkansas, Arkansas Geol. Survey, Annual Report for 1890, vol. ii.

†HAYES, C. WILLARD, The Arkansas Bauxite Deposits, U. S. Geol. Survey (in press.)

‡SPENCER, J W., The Paleozoic Group. The Geology of Ten Counties of Northwestern Georgia, *Geological Survey of Georgia*, Atlanta, 1893.

‖HAYES, C. WILLARD, The Geological Relations of the Southern Appalachian Bauxite Deposits, *Trans. Amer. Inst. Min. Engrs.*, 1894, February. Virginia Beach Meeting, Author's Edition, 12 pp
Ibid, Bauxite, *Sixteenth Annual Report U. S. Geol. Survey*, 1895, Part iii, pp. 547-597.

§MCCALLEY, HENRY, Alabama Bauxite, Proc. Ala. Industrial and Sci. Soc. 1893.
Ibid, Report on the Valley Regions of Alabama, Part. II, On the Coosa Valley Region of Alabama, *Geol. Survey* [illegible]

ga and Walker counties, Georgia. The above belt forms a part of the well known Coosa valley region in Georgia and Alabama. The ore has been mined at various points within this belt in both states.

The area in question forms a part of the southern extension of the Appalachian valley province. When viewed in detail it is composed of numerous subordinate valleys separated by more or less extensive parallel ridges, whose axial directions are coincident with the general trend of the valley province. This ridge-valley type of topography is definitely related to the rock structure of the area. The ridges mark the lines of more resistant rock, while the valleys are etched out of the soft shales and limestones. The ridges further mark the remnants of at least three rather distinct base-leveled plains, which are believed to have a direct bearing on the age relationship of the deposits, discussed elsewhere.*

In addition to the folds of the usual Appalachian type the region is characterized by two series of faults with which the bauxite distribution is very intimately associated (see map plate VII). The two types of faults are designated by Hayes† as (*a*) major thrust faults, and (*b*) minor thrust faults. The major thrust faults are characterized by great horizontal displacement and low inclination of the fault plane. Three faults of this type have been recognized and described by Hayes in this area, namely, the Coosa, Rome and Cartersville faults.

The minor thrust faults are very common in the southern part of the area and are of the ordinary Appalachian type. They have an approximate north-south direction, intersecting the main axis of the region at angles of 30° to 40°, and are characterized by rather steep inclinations of the plane, 40° or thereabouts. They vary in length from three to eight miles and cut the strata, at close intervals, into narrow strips forming monoclinals, which dip steeply toward the east. For the reason that the two types of faults are seldom found intersecting each other the faulting is inferred to belong to different and therefore distinct periods of disturbance.

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*HAYES, C. WILLARD, Op. cit pp. 551-554.

†Ibid. The Overthrust Faults of the Southern Appalachians, *Bulletin, Geol. Soc. Amer.*, 1891, vol. ii, pp. 141-154.

Ibid, Geology of a Portion of the Coosa Valley in Georgia and Alabama, *Bulletin, Geol. Soc. Amer.*, 1894, Vol. 5, pp. 465-480.

Description of the Ore.

Pronounced variation in the physical features and appearance of the ore is a prevailing characteristic, though it usually has a marked pisolitic structure. The ore varies in color from white and cream through pink to a deep red in which iron oxide is present as an essential constituent, and at times the iron oxide is equal to and may even exceed the alumina. The pisolitic type consists of concretions and matrix in nearly all proportions. The ore varies from a structureless bauxitic clay, without trace of the pisolitic structure shown, through the pisolitic type in which concretion and matrix are in about equal proportions, to the pebble type, which consists of concretions averaging three-quarters to two and one-half inches in diameter, held together by a soft and plastic putty-like clay.

The matrix varies in hardness from a soft plastic clay-like material to a dense and compact form, which breaks with a sub-conchoidal fracture; not scratched by the nail but readily scratched with a knife. It ranges in color from white and cream to the highly ferruginous deep red types, the cream-colored and dull gray tones being perhaps the most common. The pisoliths or concretions are nearly spherical in shape and range in size from the smallest pea up to two and one-half inches in diameter. The concentric structure is characteristic; the layers rarely exceeding a knife's-edge in thickness and are seldom homogeneous in color but usually alternate from white through intermediate shades to red. They may be hard and compact from centre to circumference breaking with a conchoidal fracture; or, as is more often the case, the hard outer layers may contain a powdery interior, red or white in color, and not filling the entire space or cavity—a condition probably due to subsequent shrinkage from dessication. The pebbles may be single or compound in structure according to whether they are composed of a single neucleus or of several nuclei.

With reference to structure the following types of the ore have been distinguished by Hayes:* (1) pebble, (2) pisolitic, (3) oolitic, (4) vesicular, (5) amorphous. In well differentiated portions of the ore the above types are easily recognized, but the classification is purely arbitrary since the various types

*Op. cited, pp. 562-564.

constantly grade into each other, and no definite line can be drawn.

The form of the ore-bodies as well as the structure of the material has a direct bearing on the genesis of the deposits. The ore-bodies occur in the form of distinct pocket deposits of different sizes and usually disconnected, with the vertical nearly equal to the horizontal dimensions. Several of the deposits have been entirely exhausted and the pits afford excellent advantages for observing the size and shape of the ore bodies. The largest ones were exhausted after working to a depth of about 90 feet.

The ore-bodies proper are, in every case, where worked, surrounded on all sides by white to purple, red and chocolate brown, mottled clays and kaolins. The bauxite passes by imperceptible gradations into the inclosing bauxitic clays. The ore-bodies and their surrounding bauxitic clays are further inclosed in the heavy mantle of highly siliceous residual clays, derived from the weathering of the underlying cherty dolomitic limestone. The contact between the bauxitic and siliceous residual clays is always sharp with no indications of commingling with or gradation into each other. In no instance have fragments of the associated rocks and residual clays or foreign material of any character been found in the ore-bodies proper or the bauxitic clays inclosing them. The two types of clay have evidently had, therefore, a different origin.

Geologic Position of the Bauxite.

The accompanying map indicates a range in the rocks of the region from probable Algonkian to Carboniferous in age, and includes schists, slates, limestones, shales, sandstones and conglomerates. The bauxite deposits are, however, associated with those formations which range from the Weisner quarztyte (Cambrian) to the Knox dolomyte (Silurian) inclusive. Of these formations the Knox dolomyte, which is perhaps more properly grouped as part Cambrian and part Silurian, is vastly the most important. Because of its uniformity in lithologic character and general absence of fossils from it in this region, the entire formation is grouped as Silurian. It has an approximate thickness of 3,000 to 4,000 feet, and consists of massively bedded, partially crystalline, gray siliceous, magnesian lime-

stone. The silica is distributed through the limestone in the form of segregated nodules and lenses of chert. The limestone yields upon weathering a highly siliceous clay, and the residual mantle attains considerable thickness over the entire region, leaving only scant outcrops of the fresh limestone exposed to view. The Connasauga shale (Cambrian) is next below the Knox dolomyte with an approximate thickness of 2,000 to 3,000 feet. The shales belong essentially to the aluminous type, containing as shown by analyses 20 to 30 per cent. of alumina. (See page 43.)

In the Georgia area the ore-bodies are confined principally to the Knox dolomyte and appear not limited to any particular or definite horizon in the formation, but are rather associated with all parts of it, and have therefore a somewhat wide stratigraphic range. So far as mining operations extend the Georgia bodies are inclosed in the heavy mantle of siliceous residual clays derived from the Knox dolomyte. For reasons subsequently given in this paper, the bauxite is shown not to be a residual product, as the previous sentence might imply, but its origin has been entirely different from that of the residual clays.

Associated Minerals.

The trihydrate of aluminum, gibbsite, and the silicates, halloysite and clay or kaolin, are intimately associated with the bauxite. Gibbsite is found in many of the deposits amounting to scarcely more than traceable quantities, incrusting or lining the cavities of the bauxite, not exceeding one-eighth of an inch in thickness and is readily recognized by its mode of occurrence. Halloysite is a more frequent associate than gibbsite, and occurs in the form of hard, pure white, procellaneous small nodules and lenses, irregularly distributed through the ore-bodies. It is oftentimes striated and slickensided from subsequent movement probably due to settling of the deposits. Vari-colored white to red mottled clay or kaolin is always found in large quantity inclosing the ore-bodies, and in the form of clay horses and dikes cutting the bodies in various directions and attitudes. The pisolitic structure of the bauxite passes by imperceptible gradations into the surrounding masses of structureless bauxitic clays and kaolins.

Besides gibbsite, halloysite and kaolin, commercial deposits of brown iron ore and manganese oxides, mostly psilomelane and pyrolusite perhaps, are more or less intimately associated with the bauxite deposits and have been extensively mined in several localities. The deposits of brown iron ore and bauxite are found in direct contact with each other at several localities in the district.

Chemical Composition.

While scores of reliable commercial analyses of the Georgia bauxite are available, very little has been done toward working out the exact chemical constitution of this material or attempting to establish the exact form in which it exists chemically. It has been generally assumed that the southern Appalachian bauxites, like most of the foreign material, correspond to the formula $Al_2O_3.2H_2O$, the bi-hydrate of alumina. That the assumption, however, is not warranted by the facts is evident from (1) the easier solubility of the Georgia-Alabama bauxite than that of the French ores; and (2) the uniformly lower percentage of Al_2O_3 and the proportionately higher percentage of combined water in the Georgia-Alabama ore than in the French ores, as shown in the comparison of a large number of analyses of the ore from the two countries. This is made the more apparent from the somewhat lengthy discussion which follows below.

At present, three recognized hydrates of alumina occur in nature, namely, the monohydrate, $Al_2O_3.H_2O$, known as the mineral diaspore and containing,

Al_2O_3	85.0%
H_2O	15.0%

the dihydrate, $Al_2O_3.2H_2O$, which is the general formula* given for the mineral bauxite, containing,

Al_2O_3	73.9%
H_2O	26.1%

and the trihydrate, $Al_2O_3.3H_2O$, known as the minerals hydrargillite and gibbsite, and containing,

Al_2O_3	65.4%
H_2O	34.6%

Roscoe and Schorlemmer† give the formula $(Al,Fe)_2O(OH)_4$ for bauxite, but this seems not to apply to the Georgia-

*Dana, E. S., A System of Mineralogy, 1893, Sixth edition, p. 251.
†A Treatise on Chemistry, vol. i, p. 444.

Alabama material. Phillips and Hancock* conclude, after a chemical investigation of the Georgia-Alabama bauxite, based on the solubility of the contained alumina in different strengths of sulphuric acid, that it consists of a mixture of the trihydrate, $Al_2(OH)_6$ with clay, and probably a lower hydrate, $Al_2O_3.2H_2O$. The trihydrate is the base or the essential part. In the reports issued by the United States Geological Survey on the Mineral Resources of the United States, the mineral bauxite is referred to as the trihydrate. In his report "On the Coosa Valley Region of Alabama," Henry McCalley† refers to the Alabama mineral as the trihydrate. After a study of hundreds of analyses of the French bauxites Laur‡ makes the following statement concerning their chemical constitution:

"When these minerals [bauxites] are studied, not in isolated specimens but in mass, it is quickly noticed that there is in their composition one constant, so to speak, namely, the general proportion of anhydrous alumina, Al_2O_3, the average of which is about 66 to 69 per cent. This figure is given by the analyses of thousands of shipments. Representing this constant by A, we find three variable elements, e, besides, namely, water, silica, and ferric oxide; and it is a remarkable fact, that the sum of the weights of these is constant also at about 27 per cent. We will represent it by Pe."

"Finally, the various accessory substances (titanium, vanadium, etc.) which occur even in the purest bauxites, present a constant total of about 3 to 4 per cent. These we represent by C."

"Thus, the centesimal formula of the bauxites: 68 to 70 Al_2O_3+27(SiO_2, Fe_2O_3, H_2O)+4(sundry accessories) may be written in general form as A+Pe+C."

"But the three variable elements of Pe have the singular property of replacing one another, in whole or in part, separately increasing, diminishing, or totally disappearing, without change of the total of 27 per cent., and without altering the fixed mineral species, which is, according to our view, the bihydrate of alumina, forming the base of the mineral. These varying substitutions give rise to the different types * * *"

*The Commercial Analyses of Bauxite, *Jour. Amer. Chem. Soc.*, 1898, vol. xx, p. 211.

†*Geological Survey of Alabama*, 1897, pp. 79-84.

‡The Bauxites: A Study of a New Mineralogical Family, *Trans Amer. Inst. Min. Engrs.*, Virginia Beach Meeting, February, 1894. (Author's edition, 9 pp.)

Continuing, Laur distinguishes four types of bauxite whose farmulæ are given as follows:

(1) Mixed bauxite of Baux, A+Pe........................ $\left\{\begin{matrix} \frac{1}{3}\ H_2O \\ \frac{1}{3}\ SiO_2 \\ \frac{1}{3}\ Fe_2O_3 \end{matrix}\right\} + C.$

(2) Pale bauxite of Villeveyrac, A+Pe................. $\left\{\begin{matrix} \frac{1}{2}\ H_2O \\ \frac{1}{2}\ SiO_2 \end{matrix}\right\} + C.$

(3) Red bauxite of the Var, A+Pe......................... $\left\{\begin{matrix} \frac{1}{2}\ H_2O \\ \frac{1}{2}\ Fe_2O_3 \end{matrix}\right\} + C.$

(4) Pure bauxite of Alabama, A+Pe...................... $[\ 2\ H_2O\ ] + C.$

An abstract in the Chemisches Centralblatt for 1892, page 14, of an inaugural dissertation by A. Liebreich in which an account of the derivation of bauxite from basalt with special reference to the German deposits is given, says, "chemical analyses show certain differences in the composition of bauxite from different places, the smaller amount of water in the French bauxite referring it to diaspore, while the Vogelsberg mineral is probably gibbsite (hydrargillite) [the trihydrate of alumina]."*

The writer has gotten together as many authentic analyses of the Georgia bauxites as possible, and from them the ratio of Al_2O_3 to H_2O was calculated. Also the sum of the percentage amounts of the impurities SiO_2, TiO_2 and Fe_2O_3 is given. Calculations are made and given for the two types of bauxite, namely, (a) the non-ferruginous type, in which the iron enters as an impurity; and (b) the ferruginous type, in which the iron replaces a part of the aluminum. The analyses were carefully selected, and in case of the non-ferruginous type only those which gave 55 per cent. and more of Al_2O_3 were used. This minimum percentage of Al_2O_3, 55 per cent., in the non-ferruginous type is the lowest amount of Al_2O_3 indicating the purest grade of the ore. In the ferruginous type all analyses are included which show 10 per cent. and more of Fe_2O_3.

A majority of the analyses used were obtained by analytical methods which yield the soluble Al_2O_3. On a 55 per cent. Al_2O_3 basis, however, the small percentages of insoluble residues (SiO_2) indicate that the soluble Al_2O_3 is practically the equivalent of the total Al_2O_3. This conclusion is based upon a close comparison of analyses in which the soluble

*Quoted by GEORGE P. MERRILL, Guide to the Collections in the Sections of Applied Geology in the National Museum; The Non-Metallic Minerals, 1901, p. 283.

Al_2O_3 was estimated, with others in which the total Al_2O_3 was determined. Also from analyses of several samples in which both soluble and total Al_2O_3 were separately determined in the same sample.

		Per Cent.	Molecular Ratio.		
(1)*	Al_2O_3	58.62	.574	1.00	Ratio of Al_2O_3: H_2O is nearly 1:3 corresponding to the formula Al_2O_3. 3 H_2O.
	H_2O	31.44	1.746	3.04	
	SiO_2	4.27			
	TiO_2	3.79	9.57 per cent.		
	Fe_2O_3	1.51			
	Total	99.63			
(2)†	Al_2O_3	58.91	.577	1.00	Ratio of Al_2O_3: H_2O is nearly 1:3 corresponding to the formula Al_2O_3. 3 H_2O.
	H_2O	31.59	1.755	3.04	
	SiO_2	3.34			
	TiO_2	4.18	9.39 per cent.		
	Fe_2O_3	1.87			
	Total	99.89			
(3)‡	Al_2O_3	61.67	.604	1.00	Ratio of Al_2O_3: H_2O is nearly 1:3 corresponding to the formula Al_2O_3. 3 H_2O.
	H_2O	29.85	1.658	2.75	
	SiO_2	4.77			
	TiO_2	2.95	8.10 per cent.		
	Fe_2O_3	0.38			
	Total	99.62			
(4)§	Al_2O_3	60.34	.591	1.00	Ratio of Al_2O_3: H_2O is nearly 1:3 corresponding to the formula Al_2O_3. 3 H_2O.
	H_2O	30.36	1.686	2.85	
	SiO_2	4.75			
	TiO_2	2.39	8.84 per cent.		
	Fe_2O_3	1.70			
	Total	99.54			

		Per Cent.	Molecular Ratio.		
(1)‖	Al_2O_3	61.92	.607	1.00	Ratio of Al_2O_3: H_2O is nearly 1:3 corresponding to the formula Al_2O_3. 3 H_2O.
	H_2O	30.61	1.720	2.80	
	SiO_2	2.68			
	TiO_2	3.54	7.04 per cent.		
	Fe_2O_3	0.82			
	Total	99.57			
(Average)					
	Al_2O_3		.596	1.00	Ratio of Al_2O_3: H_2O is nearly 1:3 corresponding to the formula Al_2O_3. 3 H_2O.
	H_2O		1.709	2.89	

*Average of 28 analyses, furnished by courtesy of MR. J. R. GIBBONS.

†Average of 20 analyses, furnished by courtesy of MR. J. H. HAWKINS.

‡Average of 4 analyses, furnished by courtesy of MR. B. F. A. SAYLOR.

§Average of 4 analyses, analyzed by H. C. WHITE, Univ. of Ga., Athens, and quoted by J. W. SPENCER, op. cited. pp. 215-220.

‖Average of 3 analyses, made by THOMAS L. WATSON, Lab'y, Geol. Survey of Georgia.

SiO_2 }
TiO_2 } 8.59 per cent.
Fe_2O_3 }
Total

(Ferruginous Bauxite)*

Al_2O_3	52.94... .519	.595...1.00		Ratio of Al_2O_3: H_2O is nearly 1:3 corresponding to the formula $Al_2O_3 \cdot 3\ H_2O$.
Fe_2O_3	12.29... .076			
H_2O	28.40...1.577	...............2.65		
SiO_2	2.83	6.61 per cent.		
TiO_2	3.78			
Total	100.24			

The prevailing structure of bauxite in all known workable deposits is pisolitic. So far as the writer can determine separate analyses of the matrix and concretions or pisoliths have never been made. While it is generally true that the pisolitic structure in case of the Georgia-Alabama ore grades into a structureless material, the pisoliths or concretions are as a rule perfectly sharp and distinct from the inclosing matrix, and the two may or may not have the same chemical composition. With the view of possibly determining this the writer selected specimens of the ore in the field and carefully separated matrix and pisoliths, and separately analyzed them in the survey laboratory with the results shown below. No attempt was made at separate analyses of isolated thin layers of the pisoliths or concretions from each other, and of the layers from the inclosed powder.

	PISOLITHS			MATRIX			
	Maddox	Bobo	Warrior	Maddox	Church	Watters	Perry
Al_2O_3	52.36	57.26	52.40	64.91	46.92	63.60	48.30
H_2O (combined)	33.17	31.69	24.06	33.00	21.68	27.15	28.01
SiO_2	3.74	0.99	4.21	0.62	20.46	6.43	3.17
TiO_2	9.70	7.63	8.79	1.05	9.80	1.95	9.75
Fe_2O_3	0.76	1.89	10.44	0.28	0.28	0.28	trace
H_2O at 100° C	0.20	0.39	0.39	0.53	0.34	0.56	0.53
CaO, MgO	none	none	none	none	none	none	none
Na_2O, K_2O	none	none	none	none	none	none	none
Total	99.93	99.85	100.29	100.39	99.48	99.97	99.76

The above analyses suggest more uniformity in composition for the pisoliths than for the matrix; but they further indicate

*Average of 6 analyses.

no decided appreciable difference in the composition of the two parts of the mineral.

In its purest form bauxite contains more or less foreign material either chemically combined or mechanically admixed. Iron oxide present in variable amounts, ranging from a trace to percentages equal to and occasionally exceeding that of the alumina, is usually present replacing in part the alumina, and in part only as an impurity.

Titanium is invariably present ranging usually from 1 to 10 per cent. when estimated in the form of titanium dioxide. Analyses indicate that this constituent averages higher in the pisolitic ore and is lowest in the structureless bauxitic clays. The form in which the titanium exists in the ore is seemingly dependent in large measure upon the origin of the bauxite. A study of those deposits derived from basalt and similar igneous rocks indicates that the titanium occurs in the form of free oxide or as titanic iron. This is true of the Vogelsberg deposits in Germany as shown in the study of thin sections of the bauxite by A. Liebreich; and also of the Ober-Hessen deposits by Lang. Very little if any of the titanium in the Georgia deposits exists in the form of free oxide, as a microscopic examination of a large number of thin sections of the mineral failed to indicate more than a bare trace of titaniferous oxides. Separation by means of heavy solution and by elutriation confirmed the microscopic evidence.

Silica varies from a fraction of 1 per cent to several per cent. in the purest ore, and 30 to 35 per cent. in the low grade types of material, bauxitic clays and kaolins. This constituent is usually present in the form of the hydrated aluminum silicate clay, which is invariably admixed in varying proportions with the bauxite; and is also present to some extent as free silica, as shown by the microscope.

The Georgia bauxites are usually free from traces of the additional following common impurities in bauxites of many localities: lime, magnesia, phosphoric and carbonic acids and the alkalies, soda and potash.

RÉSUMÉ: From the preceding data it is clear that the formula given by Laur for the French bauxites essentially the bihydrate of alumina and applied to the Georgia-Alabama mineral is not applicable to the Georgia deposits. The average

percentages of Al_2O_3 and H_2O in the best grade of the Georgia bauxite certainly correspond to the formula $Al_2O_3.3H_2O$, the trihydrate. In a majority of analyses a variable percentage of soluble Al_2O_3 in 100°C. of 50°B. sulphuric acid is found, which ranges from a fraction of 1 per cent. in the purest ore, to 40 and 45 per cent. in the associated bauxitic clays, which are shown to grade into each other. The insoluble Al_2O_3 is probably present in the form of the hydrous aluminum silicate, clay, admixed possibly as Phillips suggests with a lower hydrate of alumina. The Georgia bauxites, therefore, in their purest form, consist in most cases of a mixture whose base or essential part is the trihydrate of alumina. All gradations in which the soluble alumina ranges from about 60 per cent. to several per cent., or pure trihydrate of Al_2O_3, to bauxitic clay, corresponding to the hydrous aluminum silicate, are known.

As remarked by Liebreich, chemical analyses of the mineral from different localities show differences in chemical composition. Thus we have analyses which correspond to the three hydratesmono- di- and tri- of Al_2O_3, which strikingly illustrates the variable character of the so-called mineral bauxite.

So far as the writer can gather from the various accounts and descriptions in which analyses of bauxites from the principal localities, both foreign and American are given, much depends upon the origin, as to the chemical composition of the mineral. Al_2O_3 forms, however, in all cases, the basis; and it ranges from 55 to 85 per cent. according to locality, with corresponding variable proportions of water of chemical combination, ranging accordingly from 15 to 34 per cent. Thus, deposits of the mineral are known which correspond on analyses with the three hydrates of Al_2O_3.

While the so-called mineral bauxite corresponds in chemical composition, according to locality, to the three natural hydrates of alumina, as a rule, no resemblance in physical properties known at present is shown to the minerals diaspore (monohydrate) and gibbsite (trihydrate).

Since this correspondence therefore in chemical composition to the three hydrates does exist, the question is naturally suggested, whether the mono- and tri- hydrates known as the minerals diaspore and gibbsite, do not really occur with physical properties different from those usually record-

ed, and closely resembling those of the mineral bauxite? In other words, is not what is called bauxite in some localities diaspore or gibbsite in a different physical state? Or, whether the commonly accepted formula for bauxite, $Al_2O_3.2H_2O$ or $Al(OH)_3$, must be modified according to locality to correspond to mono- di- or tri-hydrate as the case may be; and the general formula to be applied irrespective of locality and in its broadest usage, written $Al_2O_3.nH_2O$, in which n is variable and may correspond to one, two or three molecules of water.

Origin of the Bauxite Deposits.

The Georgia bauxite deposits have been studied in considerable detail by Spencer and Hayes and the theories advanced by them to explain the accumulation of the ore-bodies are discussed below at some length.

Dr. J. W. Spencer* suggested the following theory to explain the accumulation of the Georgia deposits:

"This is an open question. Its situation along with the iron and manganese ores in dolomites suggests a common genesis. The formation skirts the crystalline rocks of central Georgia, whence the materials were originally obtained. Prof. Branner says that the Arkansas bauxite, although in Tertiary rocks, is located near eruptive syenites, or hornblende granites. Such rocks in Georgia have given rise, in part, to the iron and manganese minerals. The feldspar, in others, contains the aluminium, and there remains only the necessary solvent to transport and deposit it as the mineral bauxite."

"In the weathering of the rocks carbonic and vegetable acids remove the iron, manganese, lime, etc., from the hornblende, and potash and soda from the feldspar. So also carbonic acid in water can dissolve small quantities of alumina; thus the same waters can remove the iron, manganese and alumina. The alkalies derived from the decay of feldspars can also dissolve the alumina. Thus transported, the alumina may be precipitated in the lagoons in which the ferruginous and manganiferous clayey limestones were being formed. The white clays associated with the bauxite and iron ore deposits are usually of fine texture, indicative of deposition in quiet waters. The frequent re-

*The Paleozoic Group of Georgia, Geological Survey of Georgia, Atlanta, 1893, pp. 225-226.

placement of part of the alumina by ferric oxide further shows the presence of both metals in the original solution, but invariable quantities at different times and places."

"Upon the subsequent decomposition of the Knox limestone, the calcareous matter being removed, the ores were concentrated, leaving accumulations of bauxite more prominent than in the original beds."

"The position of the bauxite appears to be more or less in pockets and lenticular masses in certain strata, and if workings are ever carried beneath the decayed rocks, the mineral will likely be found in pockets in compact limestone. Indeed, some of the apparent clays may be found to be the soluble aluminous mineral, which is so far as known in Georgia, generally more or less oolitic and concretionary, as are the iron and manganese deposits. The bauxite beds or pockets are less interrupted, and are much more extensive than the latter named mineral."

Briefly summarized Dr. Spencer's explanation for the accumulation of the bauxite deposits is: (a) The source of the alumina was from the crystalline rocks of central Georgia; (b) the alumina was carried to its present place by carbonated or alkaline waters and precipitated in the lagoons in which the ferruginous and manganiferous limestones were being formed; and (c) the ore was further concentrated upon weathering of the Knox limestone, the soluble calcareous material of which was removed in solution, and the insoluble aluminous material, bauxite, was accumulated and left more prominent than in the original beds.

This theory fails to explain the following essential conditions and characteristic modes of occurrence of the Georgia deposits. (1) The deposits are compact ore-bodies existing in the form of well-defined pockets and, as a rule, with the vertical nearly equal to the horizontal dimensions. This mode of occurrence cannot by any known process apply to the accumulation of ore-bodies resulting from weathering. (2) The relationship of the bauxite and its associated kaolins to the surrounding residual siliceous material. In no instance has the gradation from the bauxitic clay into the inclosing residual clays been observed; but on the contrary, the line between the two is at all times definite and pronounced. The two types of clay bear no resemblance to each other. Furthermore the ore-

bodies are free from included residual material. The concentration or accumulation of ore deposits from weathering *in situ* usually shows more or less residual material variously admixed, which forms the most convincing evidence in the case of deposits derived from rock weathering. This point is abundantly illustrated in the manganese and some of the iron deposits in the same region. (3) The relation of the deposits to the present topography of the region and their altitude above sea level. Upon Dr. Spencer's theory the ore-bodies if they represent accumulation from weathering of the Knox limestone should only occur at definite and uniform positions in that formation. On the contrary the deposits do not conform to these conditions, but are found in all parts of the Knox dolomyte, giving as Hayes* has shown, a stratigraphic range of at least 4,000 feet. (4) While the bauxite deposits in question are somewhat closely associated with those of iron and manganese, more particularly the iron, it by no means follows that the conditions suggest a "common genesis." In fact, recent work in this area conclusively demonstrates that the three types of ore-bodies are not of a common genesis. The manganese deposits of the Cartersville district represent undoubted residual accumulations concentrated by physical and chemical processes incidental to weathering. The ore deposits of iron and manganese are more intimately associated than any two metalliferous deposits known in the area and yet with several exceptions they have had a different origin.

The above facts constitute some of the essential features of the bauxite deposits which must be accounted for in any satisfactory explanation.

After a detailed study of the structural geology of the region and of the ore-bodies Dr. C. W. Hayes† suggests a theory for the origin of the Georgia deposits which is entirely different from the one formulated by Dr. Spencer. Hayes' theory is briefly stated by him as follows:‡

"The deposits are there [Georgia-Alabama region] found embedded in residual clay derived from the weathering of limestone. The limestone overlies a great mass of shales, and the

*Op. cited.

†Bauxite, *Sixteenth Annual Report. U. S. Geol. Survey*, 1895, part iii, pp. 587-591. This contains a very full and detailed statement of Dr. Hayes' theory.

‡Taken from the proof copy of Dr. Hayes' very valuable paper on "The Arkansas Bauxite Deposits," not yet issued from the press, but the author Dr. Hayes very kindly placed at my disposal a proof copy of the report.

formations are intersected by numerous faults, along which water has in the past found easy access to great depths. The shales are made up largely of silicate of aluminum. They also contain considerable iron sulphide in the form of pyrites. It is believed that the surface waters, carrying oxygen in solution, gained access to these shales and, by oxydizing the pyrites, set free sulphuric acid. This, under the conditions present, decomposed the aluminous shales, forming alum and sulphate of aluminum. Ascending currents carried these salts in solution to the surface, and, coming in contact with the limestone during their upward passage, they were decomposed, forming sulphate of lime and aluminum hydroxide, together with basic sulphate of aluminum, which was subsequently changed to aluminum hydroxide on exposure to the air. The aluminum hydroxide thus produced formed a gelatinous precipitate which collected about vents of springs. It was kept in motion by the ascending water and thus formed concentric structures. The reactions indicated above are all known to take place in nature, and the process is one which is readily understood."

The essential facts which a satisfactory theory for the origin of the Georgia deposits of bauxite must explain are now stated in full. Some of these were stated in connection with Dr. Spencer's theory:

(1) The bauxite deposits in the Georgia district are mostly confined to the Knox dolomyte. They are not found at any uniform position in the dolomyte but are associated with all parts of the formation, giving a wide stratigraphic range.

(2) The ore occurs in the form of distinct pocket deposits of varying sizes and disconnected, with the vertical nearly equal to the horizontal dimension.

(3) The absence of foreign material, such as might be derived from the inclosing rocks in the ore-bodies and their associated bauxitic clays and kaolins. The pronounced difference in the bauxitic clays and the inclosing residual siliceous clays with no indication of commingling with or gradation into each other,

(4) The location of the deposits with reference to altitude and topography. Some of the ore-bodies occur below the 850-foot level, and a few are found above 950 feet; but where

erosion has not removed any considerable part of the deposits they are generally found near the 900-foot level.

(5) The prevailing pisolitic structure of the bauxite. The process producing the same structure in calcareous and siliceous materials has been observed and described. In such cases, where the process has been observed the pisolitic structure resulted from the deposition of the material in solution or from suspension in the form of a fine precipitate. Very likely, as Hayes says, this applies to all material having a pisolitic structure.

(6) The grouping or occurrence of the ore-bodies along apparent lines of weakness and about certain centres. Reference to the accompanying map makes this point clear.

(7) No eruptive rocks are yet known in the vicinity of the deposits, nor do any rocks occur in the region which by weathering could yield bauxite as a residual product.

The theory which best conforms to these premises is the one outlined by Dr. Hayes and briefly stated above, which as set forth by its author is based on the three essential features required of any satisfactory theory, namely: (1) the source from which the material was derived; (2) the means by which it was transported; and (3) the process of its local accumulation. Only the leading points under each one can here be stated.

(1) *The Source of the Alumina*: The Knox dolomyte, with which the deposits are associated, contains, as shown by numerous analyses, a very small percentage of alumina, which, by the process of accumulation required, is thought to be entirely inadequate as the source of the material.

Four analyses showed the composition of the Knox dolomyte to vary within the following limits:

SiO_2	3.75	to	7.252	per cent.
Al_2O_3, Fe_2O_3	1.236	to	1.76	" "
$CaCO_3$	34.07	to	53.44	" "
$MgCO_3$	36.32	to	55.736	" "

The following analyses of the Knox dolomyte and its accompanying residual clay from Morrisville, Calhoun county, Alabama, were made by Dr. W. F. Hillebrand* and described by professor I. C. Russell.† They are inserted here to illus-

*Bulletin, U. S. Geol. Survey, No. 168, 1900, pp. 258 and 295.
†Ibid, No. 52, 1889, pp. 24-25.

trate the chemical changes incident upon the weathering of this rock. In his description of the magnesian limestone professor Russell makes the following statement: "The original rock in this instance was a grayish-white dolomyte typical of its class over a large area in the southern part of the Great Appalachian valley, while the clay left by its decay is a fair sample of the red soil of the South."*

Constituents.	Fresh Dolomyte	Residual Clay
SiO_2	3.24	55.42
Al_2O_3	0.17	22.17
Fe_2O_3	0.17	8.30
FeO	0.06	trace
MgO	20.84	1.45
CaO	29.58	0.15
Na_2O	——	0.17
K_2O	——	2.32
H_2O at 110° C.	0.30	2.10
H_2O above 110° C.		7.76
CO_2	——	——
Total	99.90	99.84

As indicated by the above analysis the residual product clearly represents a highly siliceous ferruginous clay, in which only a trace of the original more soluble calcium and magnesium salts is retained.

This Knox dolomyte, is underlaid, however, everywhere in the district by several thousand feet of calcareous clay or aluminous shales, which, as shown by the analyses below, contain 20 to 30 per cent. of alumina, in addition to the other constituents commonly found in the deposits, such as silica, titanic and iron oxides.

The following analyses indicate the general composition of the middle Cambrian shales of the bauxite region:

	I.	II.
SiO_2	55.02	52.82
Al_2O_3	21.02	26.17
Fe_2O_3	5.00	9.46
FeO	1.54	....
MgO	2.32	1.08
CaO	1.60	trace

*Ibid, p. 24.

I. Middle Cambrian shale. Coosa valley, near Blaine, Cherokee County Alabama. Dr. H. N. Stokes, analyst. *Bulletin No. 168 U. S. Geol. Survey* 1900, p. 283.

II. Oostanaula shales about two miles northwest of Cartersville, Bartow County, Georgia. J. W. Spencer, Paleozoic Group, Geol. Survey of Georgia, 1893, p. 285.

Na_2O	0.81	0.20
K_2O	3.19	2.71
H_2O at 110° C	2.44	0.23 (hygroscopic.)
H_2O above 110° C	5.65	7.00 (combined).
TiO_2	0 65	....
P_2O_5	0.06	....
MnO	trace	....
BaO	0 04	....
SrO	trace	....
Li_2O	0.03	....
SO_3	0.02	....
Cl	trace	....
CO_2	0.83	....
Carbonaceous matter	0 32	....
Total	100.54	99.67

The Connasauga shales (Cambrian) are believed therefore to have been the source of the material.

(2) *The Means of Transportation*: The formations of the district, both limestone and shale, are intersected by numerous faults, which afforded in the past easy access for the percolation of waters. The descending waters carrying oxygen in solution reacted chemically on the aluminous shales, which contained disseminated pyrites, taking into solution the sulphates of aluminum and iron, which salts were returned to the surface by the ascending waters. The upward passage of these salts in contact with several thousand feet of limestone resulted in a further chemical reaction, forming probably, as in the chemical laboratory, aluminum hydroxide and basic sulphate of aluminum.

(3) *The Process of Accumulation*: The ascending currents bearing the aluminous salts in solution are believed to have reached the surface near or upon the fault lines forming large springs, which were probably thermal, and the aluminum hydroxide produced as described by Hayes formed a gelatinous precipitate, which collected about the vents of the springs. "From analogy with pisolitic sinter and travertine now forming such conditions would appear to be highly favorable for the production of the structure actually found in the bauxite. The precipitate was apparently collected in globular masses by the motion of the ascending water, and constant changes in position permitted these to be coated with successive layers of more compact material. Finally after having received many such

coatings, the pisoliths were deposited on the borders of the basin, and the interstices were filled by minute oöliths formed in a similar manner or by the flocculent precipitate itself. Slight differences in the conditions prevailing in the several springs, such as concentration and relative proportion of the various salts in solution, also temperature and flow of the water, would produce the variation in the character of the ore observed at different points."

The theory above outlined was originated and applied by Dr. Hayes to the Georgia-Alabama deposits. It is here reviewed and discussed at some length for the reason that after a careful study of the same region by the writer, Dr. Hayes' theory more completely covers the essential features required of a satisfactory theory and explains the conditions in the field as the writer saw them, than any one yet advanced.

Age of the Deposits.

Dr. Hayes* has given an excellent presentation of the physiographic development of northwest Georgia, and the contiguous parts of Alabama and Tennessee. Hayes points out in this development three levels of planation in the bauxite area, the two oldest ones corresponding in age to the Cretaceous and Eocene periods, respectively. It is further shown that the surfaces of the dolomyte plateau and ridges of the bauxite region determine the Eocene base-level plain, corresponding to an altitude of about 950 feet above sea level. The majority of the bauxite deposits where not deeply eroded are found between the levels of 900 and 950 feet. Since the altitude of the deposits corresponds closely to that of the Eocene peneplain, they could not have been formed previous to that time as the ore-bodies are shallow surface deposits. Nor could they have been formed after the plain was uplifted and eroded without changing the place of deposition of the ore-bodies. This would apparently fix the age of the bauxite deposits sometime near the close of the Eocene.

*Op. cited, pp. 551-562.
Physiography of the Chattanooga District, in Tennessee, Georgia, and Alabama. *Nineteenth Annual Report, U. S. Geol. Survey*, 1897-98 (1899), part ii, pp. 1-58.

THE AGE OF THE KANSAS-OKLAHOMA RED-BEDS.

By J. W. BEEDE, Effingham, Kansas.

The "Red-beds" of Kansas and Oklahoma have been referred to all the geologic periods from the Permian to the Cretaceous inclusive. Until recently no fossils have been known from these deposits. The thickness of these beds in Kansas is about 1,150 feet.

A few years ago Prof. C. N. Gould found some imperfectly preserved ostracod crustaceans which Mr. T. Rupert Jones referred to a Triassic group of the genus *Estheria* under the name *Estheria minuta*. A little later Prof. Gould found some excellent specimens of *Eriops*, a Permian vertebrate, associated with these same fossils, all of which came from near the base of the beds, leaving the age of a majority of them still in doubt, especially those above the great gypsum beds.

Last summer professor Gould, with a party of the Oklahoma geological survey, discovered fossil invertebrates at Horse Springs, west of Alva, O. T., above the Cave Creek gypsum nearly at the top of the red-beds. The fossils were submitted to the writer for identification and later to Mr. Charles Schuchert, who offered some valuable suggestions. They are mainly pelecypods with a species of brachiopod and a few gastropods.

Though no species of *Conocardium*, so far as I am aware, is known from the Lower Permian of Kansas or Oklahoma, yet this Carboniferous genus is represented in the collection. *Aviculopecten occidentalis* (Shum.) Meek, is also present and one other species bearing somewhat of a resemblance to it but quite different from it in some respects, is also present. One of the common fossils is a biplicate terebratuloid, *Dielasma schucherti* Beede,* belonging to a group of this genus heretofore unknown in the American Permian. Mr. Schuchert informs me that it is very similar to a species of this genus described by Waagen from the Permian of Europe.

Among the other genera represented are *Schizodus*, *Naticopsis* and *Pleurophorus*.

* See forthcoming *Rep. Geol. Surv. O. T.*

The presence of these fossils clearly demonstrates the Permian age of these rocks, coming as they do from very near to the top of the beds.

Taking this into consideration the thickness of the Permian in southern Kansas is about 2,300 feet, allowing 1,150 feet for the Upper Permian (red-beds), and 1,150 feet for the Lower Permian (Wellington, Marion, Chase and Neosho).

A SHORT DISCUSSION OF THE ORIGIN OF THE COAL MEASURES FIRE CLAYS.

By T. C. Hopkins, Syracuse, N. Y.

Fire clay is one of the terms in common usage that has been adopted into geological literature and it is not possible to give a scientific definition that would cover its usage by all classes. The manufacturers use the term for a highly refractory clay, although they probably would not all agree on the degree of refractoriness that a clay must have to be properly termed a fire clay. Professor Wheeler draws the line at 2,500° Fahrenheit;* that is, a clay that withstands a temperature of 2,500° without fusion may be properly designated a fire clay. The coal miner and the clay miner in the coal region use the term for all the clays that underlie the coal seams, and likewise for all the blue clays of the Coal Measures whether underlying coal seams or not. Chemically, fire clay is a nearly pure hydrous silicate of alumina; especially must it have a low percentage of the so-called fluxing materials, such as the alkalies, alkaline earths, and iron oxides.

From the standpoint of the manufacturer and the chemist many of the blue clays and many of the under clays are not fire clays at all. On the other hand the interpretation given by the miner and the prospector leaves out a great many of the high grade refractory clays which are not blue and do not occur in the Coal Measures. However, the miners' use of the term, as applied to the Coal Measures, is a natural and a convenient one, as it is not always possible to tell in a field examination the difference between clays that fuse at 2,500 degrees and those that do not. In many of the different geological reports the term has evidently been used in this way. When the

* *Missouri Geological Survey*, vol. xi, p. 133.

chemical and the fire resisting qualities have later been determined in the laboratory they can then be distinguished as pure and impure, high grade and low grade, or poorly refractory and highly refractory.

While the present paper deals principally with the blue clays of the Coal Measures, the term fire clay, of course, cannot properly be limited to these clays, as valuable refractory clays occur in strata both older and newer than the Coal Measures without any connection with coal seams of any kind. Thus, in Missouri, fire clays occur in Lower Carboniferous, Silurian, and Ordovician strata and in New Jersey in Cretaceous or more recent. Many of the residual kaolins of the Piedmont belt are highly refractory.

The explanation commonly offered for the origin of the blue fire clays of the Coal Measures is that they are the soils on which grew the vegetation that forms the coal seams lying on top of them, and the reducing and leaching action of the vegetable acids from the living and the decaying vegetation has changed the common clay to the refractory fire clay. This appears to be a satisfactory explanation for many of the clays, but there are some of the deposits that are not satisfactorily explained in this way.

The deoxidizing and leaching action of both living and decaying vegetation is illustrated in many of the bogs and swamps of the present, and in a less degree in the meadow and the forest soil. The organic acids of the vegetable matter are strong reducing agents and under their action the red and yellow ferric oxides are changed to the lower gray or bluish ferrous oxide in which form it is soluble in the acids, and where there is sufficient circulation the iron may be either carried away in solution or segregated into beds of iron ore. Fragments of minerals containing alkalies and alkaline earths may be broken up by the vegetable acids into separate compounds and the alkaline substances dissolved in the water and part carried away in solution and part may be taken up by the plants and held in the carbonaceous matter of the muck of the bog of the present or the coal bed of the older period. It sometimes happens that there is better drainage into the bog than out of it, and the iron leached from the surrounding region may be carried into the bog and deposited as an iron ore.

The general order of occurrence is first the clay overlain by the ore, followed by the coal, but it frequently happens that one or more of these substances are lacking. Sometimes it is the ore, sometimes both the ore and the coal, and less commonly the clay. That is, in some places coal seams occur without any underlying clay, and in many places the clay occurs without any overlying coal. Again, it frequently happens that the clay may form one or more seams in the coal bed; thus, in the famous Pittsburg coal seam in southwestern Pennsylvania, and in West Virginia, the inclosed fire clay seams, several in number, are remarkably persistent and regular in thickness over wide areas.

We find some phenomena in connection with the occurrence of the fire clays, and the coal seams that are difficult to harmonize with the above outlined theory of origin. Thus, if the fire clay is the soil on which grew the vegetation that forms the coal, and in so doing changed the common clay to fire clay, how are we to explain (1) the occurrence of fire clay beds free from coal of any kind, (2) that such clay is frequently of better quality, that is, more refractory than that which is overlain by coal, (3) the great thickness of some of the beds, and (4) the coal seams deposited on yellow shales or sandstones entirely independent of any fire clay?

(1) *Fire clay beds not overlain by coal.*—Comparatively little is given on this point in the literature, but the observations of the writer in several different coal basins lead him to think that this is a rather common occurrence. In Clearfield, Indiana, Westmoreland, Clinton, and Tioga counties, Pennsylvania, these coalless fire clay seams occur in considerable numbers.

The fire clay in these cases might have been formed in the usual way, and the absence of the coal explained by the fact that (*a*) the carbon might have been oxidized, owing to long exposure before the overlying sediments were deposited, or (*b*) the carbonaceous material may have been eroded before the deposition of the next stratum. (*c*) Another and, in some instances more probable explanation, is that the clay was fire clay before it was deposited in its present position, that is, it was changed to fire clay in some other locality and was then eroded and transported as sediment and deposited in its present position in much the same condition as it is at present.

(2) *The clays that occur free from the coal seams are apt to be more refractory than those underlying coal seams.*—It is a matter of observation that the most refractory clays in the Coal Measures are found among those which have no coal overlying them. This may be due partly to greater original purity and partly to a leaching subsequent to the elevation of the land. Thus the secondary deposition of the clay would tend to remove a greater percentage of the soluble bases that form the fluxing constituents and after the elevation of the land the leaching by the meteoric waters would tend to still further remove the soluble materials. The texture of clay is not favorable to the rapid percolation of water, but the slow circulation through a long period of time may accomplish the same result. The accumulation of the iron carbonate ("the ore balls") so abundant in some places, shows that the water does percolate through the clay to some extent. Where the clay is overlain by coal, the tendency is often the opposite to the above and iron is carried into the clay from the oxidizing pyrite in the overlying coal.

(3) *The great thickness of some of the clay beds.*—In some places the fire clay deposits are thirty feet or more in thickness. One can hardly conceive how the vegetation growing on the top of a deposit of this thickness would extract the iron and the alkalies from the entire body of the clay. If it were formed in this way one would naturally expect the upper part to be the purest, and at least some considerable portions of the middle and lower portions to be unchanged. Instead we find, so far as there is any difference, that the lower part is likely to be the best clay and the poorest part at the top.

At Bolivar, Pa., the flint fire clay is over twenty-five feet thick and overlying it between the clay and the coal there are several feet of shale. How would it be possible for the plants of this coal seam to leach out the iron and alkalies from twenty-five feet of clay when there are several feet of unchanged shale lying between them?

At Blossburg, Pa., there is a bed of fire clay 15 to 25 feet thick, with no coal or carbonaceous matter associated with it, and no fossil plant remains in so far as known. The laminated structure of this deposit is additional evidence in support of the belief that the clay was fire clay at the time of its deposition and not clay that has been changed in situ.

(4) *Coal without under clay.*—In most cases the coal is underlain with clay of some kind, but in many instances it is not fire clay in the sense of being highly refractory. In some instances there is no under-clay of any kind, but the coal is both underlain and overlain by a ferruginous sandstone. While in some instances casts of plant roots and stems occur in the underlying sandstone, it frequently happens that there is no evidence of vegetable remains nor any of the leaching action of the reducing acids.

In view of the above statements it appears to the writer that the occurrence of a not inconsiderable portion of the fire clays is better explained by considering them as transported clays reduced before deposition. This does not invalidate the common supposition that many of the fire clays are formed in situ by the action of the vegetation of the coal beds, but not all of them are satisfactorily explained in this way. Furthermore, the refractory quality of many of the clays has been increased probably since the elevation of the land areas by a leaching out of the fluxing materials due in part to the topographical position of the beds near the hilltops and in part to a stratigraphical position that permits the access of the acidulated waters.

NOMENCLATURE OF THE CAMBRIAN FORMATIONS OF THE ST. FRANCOIS MOUNTAINS.

By CHARLES R. KEYES, Des Moines, Iowa.

The group of granite peaks, lying at the eastern end of the Ozark highlands and to which the name St. Francois mountains has been appropriately applied, has surrounding it a thick sequence of sandstones and limestones. Regarding the geological age of these rocks there has been more or less extended discussion. The terranes recognized in the special report* on the Mine la Motte district have not the same delimitation, nor the same names, as those adopted in other descriptions of the region. Some confusion appears to exist in consequence. A brief historical statement at this time will embrace the reasons for following the nomenclature proposed in the special report mentioned.

*Missouri Geological Sur., vol. ix, pt. iv, 1895.

By paralleling the general sections, the exact stratigraphical relationships of the various formations may be clearly represented.

WINSLOW, 1896.	KEYES, 1895.
	?
Potosi limestone	?
	Le Sueur dolomyte
St. Joseph limestone	Fredericktown dolomyte.
La Motte sandstone	La Motte sandstone
Iron Mountain conglomerate	

The names defined by Winslow were incidentally mentioned by him a year previous* to the publication of his descriptions, but at that time without definition. When they were formally proposed† another set of names had been defined for the same region.

Stratigraphically, the Iron Mountain conglomerate cannot be considered as a distinct geological terrane, unless the original signification of the title be wholly changed and restricted to the conglomerates encircling the peak of Iron mountain alone. On the same horizon of unconformity and over a large area, similar conglomerates occur. These beds are not only not continuous, but they are often widely isolated and usually of very local extent. Moreover, if it were desirable to have a name undefined stand for this conglomerate the term suggested would have priority in another sense. It was used with definite application to the porphyry of the region.‡ The recognition of the porphyry as a distinct formation is all the more significant since it has been found that it is really the upper part of the general granite mass of the area.§ The conglomerates when they occur may be properly regarded as local basal facies of the La Motte sandstone.

In both of these sections mentioned above, the stratigraphical delimitation of the La Motte sandstones is essentially the same. The same is true, to all practical intents, of the Fredericktown formation. Regarding the title St. Joseph that is used in the bulletin‖ of the Federal survey, it may be said that the definition of the formation was not published until a year after that

**Missouri Geol. Sur.*, vol vi, 1895, p. 331.
†*Bull. U. S. Geol. Sur*, No. 132, 1896, p. 11.
‡*Missouri Geol. Sur.*, vol. vi, 1894 p. 30.
§*Bull. Geol. Soc. America*, vol. vii, 1896, p. 363.
‖*U. S. Geol. Sur.*, Bull. 132, 1896, p 11.

of the Fredericktown.* To be sure, the title St. Joseph appears in the lead and zinc report of Missouri, published in 1895, but it was merely a name in a table of provisional formations, and was given as an alternate with St. Francois limestone. In spite of this fact, this name might have been adapted at the time in the special report on the Mine la Motte district and used in place of Fredericktown had it not been for the circumstance that essentially the same name had been previously proposed† in due form for an important terrane in northern Arkansas—the St. Joe marble formation.

The LeSueur dolomyte‡ of the Mine la Motte district, represents only about the lower third of what was later denominated the Potosi limestone. The latter name, moreover, like St. Joseph, was merely mentioned in the general lead and zinc report. As a matter of fact, little is really known about the stratigraphy of what is colored as the Potosi limestone on the map accompanying the bulletin of the United States Geological survey. And it is exceedingly doubtful whether the beds which have been termed the LeSueur in the Mine la Motte district are represented at all in the Potosi limestone further north near the typical locality.

EDITORIAL COMMENT.

THE SUPPOSED RECENT SUBMERGENCE OF SIBERIA.

Prof. G. F. Wright finds that the country skirting the great central Asiatic table-land is loaded with the fine deposit known as "Loess." This consists of water-borne deposit for the most part though in the east the aeolian origin as maintained by professor Richthofen, seems very probable. If this material is of glacial origin ultimately, as is the case in other parts of the world, this view merely explains its mode of deposition. It must, then, be the "glacier-milk" of the glacier-system of the central plateau brought down by the rivers that flow down the long slopes and dropped on the lowlands adjoining.

But professor Wright says that the altitudes of the strata of loess are such as to prove a subsidence of the whole region in-

**Missouri Geol. Sur*, vol. ix, 1895, pt. iv, p. 48.
†*Arkansas Geol. Sur.*, Ann. Rep. 1890, vol. iv, 1893, p. 253.
‡*Missouri Geol. Sur.*, vol. ix, pt. iv, 1895, p. 52.

cluding northern Russia, most of Siberia and the area south to the Black and Caspian seas and to L. Balkath to the extent of between 2,000 and 3,000 feet. All this area was, he thinks, below the surface of an inlet from the Arctic ocean at a date comparatively recent, well within the human era, and approximately corresponding in time with the glacial era in other parts of the world.

Should this depression and submergence, on further investigation, prove to have really occurred it will be of some assistance in accounting for the absence of glacial phenomena over the great northern plains of Siberia. Already has the suggestion been put forward, but the evidence alleged in its support has not been conclusive. Nor indeed does that urged by professor Wright amount to positive proof, even in the opinion of its author. The occurrence of enormous masses of loess near the plains where glacier-streams or glaciers issued from the vast central plateau is naturally to be expected and possibly the accumulation of this material in such places may be explained without requiring so extensive submergence. These are the places where it would naturally be dropped and the occurrence of sand or gravel or even pebbles is not inconsistent with this view.

But on the other hand the absence of marine remains of every kind is opposed to marine origin of the loess. Possibly these may be found hereafter on more extensive examination, but until they come to light we must hold the subsidence and submergence theory lacking in its most valuable proof. To assume this absence would be premature. Siberia is an enormous area and its geology is little known. The future may reveal such fossils yet unknown. Thus far, however, we have no knowledge of their occurrence. And it would be scarcely safe to assume a submergence so extensive on the evidence of "loess" alone. Granting a glacial era on the high, bleak and windy "Panier" the bordering valleys might well be filled with loess even to their upper levels. E. W. C.

LABORATORY AND LECTURE METHODS IN GEOLOGY AT THE STATE UNIVERSITY OF IOWA.

The country around Iowa City is thickly covered with drift and loess, and while it affords excellent opportunities for the study of Pleistocene geology, illustrative material for

other branches of the science are far from abundant. The scarcity of material at hand has been a factor in the development of the methods used by professor Calvin.

Textbooks and other literature are recommended, and the students' reading is directed, but no definite assignments are made, nor is any attempt made to follow the text in the presentation of the subject. The department is stored with a great variety of specimens illustrative of dynamical, physiographic, and historical geology. These materials are in daily use, and it is one of professor Calvin's maxims, that a lecture in geology without specimens to illustrate it, is an imposition. The lecture-room is furnished with table-like desks accommodating eight students each, and affording room for the free use of specimens during the lectures. Rapid chalk-sketching and tabulation are used whenever the subject under discussion makes it possible.

Perhaps the most unique feature of the methods, is the constant use of camera and lantern. The camera had been made to bring the outside world into the classroom, and large collections of lantern slides and sets of photographs are used to illustrate the grander structural and physiographic phenomena. In addition to this use of photography, each student, during the course gets between sixty and seventy large kallitype plates to illustrate his permanent notebook. These plates include over five hundred figures of physiographic features, structural forms and fossils. The students furnish the paper, and it is sensitized and printed in the department laboratory. Students who can do so, may use the negatives and make their own plates.

The outlines of lectures taken in the classroom are elaborated and the work is re-written on flat paper and bound with the plates in patent covers. These permanent notebooks are called in, corrected and graded twice a term. With classes that meet five times a week, written or oral reviews are given about once a week.

Regular field trips are made as frequently as possible. Before the close of the year, each student collects material from all sources in the neighborhood of the city and presents it in the classroom with a written sketch of the geology of the region.

D. R. G.

RIVER PROFILES.

An interesting and valuable publication of the Department of Hydrography of the United States Geological Survey on the Profiles of Rivers in the United States by Henry Gannett, has just been published and is now available for distribution. It embodies within 100 pages the leading facts of about 150 of the most important rivers and streams of the country, noting their length, drainage area, the location of water power in their courses, their peculiarities of flow and the nature of their drainage basins.

The rivers selected are those which are the largest in size and bear most directly upon the varied interests of the country such as the Connecticut, Hudson, Susquehanna, Ohio, Potomac, Mississippi, Missouri, Platte, Colorado, Sacramento, Columbia, and others. The figures for the tables showing hight above sea level and fall per mile were collected from various sources. Some were obtained from the report of the Chief Engineer of the United States Army, some from railroad companies when their lines cross the streams and some from the atlas sheets of the United States Geological Survey.

In the case of such rivers as the Connecticut, Susquehanna, Mississippi and Colorado, where the surrounding country is, in part or whole, of peculiar physiographic interest, very excellent and vivid descriptions of its leading physical characteristics are given which add to the interest and render it valuable from an educational standpoint in geographic and physiographic instruction.

The pamphlet is the result of much careful work and is the first attempt to collect and compile this information in its present form.

GUIDE TO THE GEOLOGY OF NIAGARA FALLS.

We referred in the last number of the GEOLOGIST to Mr. G. K. Gilbert's résumé of the Falls of Niagara, and to the map of the region lately issued by the United States Geological Survey. More recently a more complete "guide to the geology and paleontology of Niagara Falls and vicinity" has been published by the New York State Museum, as Bulletin No. 54, vol. ix, April, 1901. It is by Dr. A. W. Grabau, of the Rensselaer Polytechnic Institute, at Troy, N. Y. It also contains a glossary of pale-

ontological nouns and adjectives not generic nor specific, these being gathered in an index. The preface is by Dr. John M. Clarke. This work is accompanied by a geological map of the Niagara river by Dr. Grabau, and by several plates showing natural scenery. Dr. Clarke states that it is a volume produced by the co-operation of the Buffalo Society of Sciences and the department of paleontology of the New York State Museum, but the work of collection of the data and the discussion of the same is wholly by Dr. Grabau. It is very thoroughly and carefully done, and the volume certainly constitutes a suitable and creditable summary of the work of the century bestowed by geologists on the features of the cataract and its gorge, and on their pleistocene history. The geologists of the coming century, having this epitome and guide, will certainly have no mean opinion of the labor of their predecessors on this greatest object lesson of pleistocene geology.

The investigations of Hall, whether on the measurements of the gorge or on the rocks and their fossils, in 1837-43, of Lyell, Logan, Gilbert, Upham, Spencer, Leverett, Taylor and others, and their aggregate results, are here cast into one mold, from which is obtained a consistent general history of the gorge and of the falls. The volume, however, is more than this. It discusses the entire geologic history of the region, detailing the physical changes which were introduced by the successive epochs. It also enumerates, with brief descriptions and numerous illustrations, the fossils that have been found in the region pertaining to the Silurian. The fossils of the Devonian are not enumerated. The last chapter is a distinct contribution to science, being a complete catalogue, with descriptions and references to authorities of the post-Pliocene fossils of the Niagara gravels, by Elizabeth J. Letson, director of the museum of the Buffalo Society of Natural Sciences. These post-Pliocene fossils are from Goat island, Prospect park, Queen Victoria park, Muddy creek, Whirlpool (both sides of the river) and Foster's flats. These fossils are also described and illustrated. The appendix consists of a "partial bibliography of the geology of Niagara and the great lakes."

The volume is destined to become a classic of geological literature, equally suitable for the drawing room and the class-room. N. H. W.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Nitrates in Cave Earth. By HENRY W. NICHOLS. (*Jour. Geol.*, Vol. IX, pp. 236-243.)

This is in the main a criticism of the theory advanced by Hess (*Jour. Geol.*, Vol. VII, p. 2) that the nitrates of cave earth are not derived to any great extent from bat guano, as has been formerly supposed, but from the soil above by a leaching process followed by a deposition of the salts on evaporation. The chief objections raised by Mr. Hess to the old theory may be briefly summarized as follows:—1. Bats do not penetrate far into caves, which makes it difficult to account for the presence of salts derived from guano and their uniform distribution in the caves. 2. Cave earths contain little or no organic matter. 3. While the total phosphates in the guano and underlying earth are about equal, the soluble phosphates are much less in the earth. In criticising these objections it is shown, that bats do penetrate into remote parts of the caves, that in some instances cave earths do contain organic matter and that the lack of soluble phosphates in the earth is due to a simple reversion of the soluble to an insoluble form. Among other things to which attention is called is the presence of carbonates in the drip waters of the cave and their absence in the cave earths, a fact which Mr. Hess's theory does not account for. It is thought that the amounts of phosphates and nitrates taken into solution from the soil are too small to account for the amounts found in the earth and that the considerable quantities of soluble salts in the bat guano furnish a more probable source of supply. The author therefore concludes that the old theory agrees with the facts better than the new. C. H. W.

Mohawkite. By JOSEPH W. RICHARDS. (*Am. Jour. Sci.*, *161*, 457-458.)

Under the name mohawkite a mineral was described by Ledoux (*Eng. & Min. Jour.*, Apr. 7, 1900,) to which he assigned the formula $(Cu\,Ni\,Co)_4As$. Later the correctness of his work was called into question by Koenig, who appropriated the name mohawkite for a mineral which he described (*Am. Jour. Sci.*, Dec., 1900,) as having the composition $(Cu\,Ni\,Co)_3As$. A new analysis is reported in the present paper, confirming the correctness of Ledoux's work and proving the existence of a molecule $(Cu\,Ni\,Co)_4As$. The name ledouxite is proposed as a name for the latter. C. H. W.

On the origin of the Phenocrysts in the Porphyritic Granites of Georgia By THOMAS L. WATSON. (*Jour. Geol.*, Vol. IX, pp. 97-122.)

A detailed petrographical description is given of the porphyritic granites of Georgia, within the Piedmont plateau. The different areas are taken up according to their geographical distribution. The following facts given by the author concerning these rocks are believed to indicate that the phenocrysts (orthoclase) have been formed in place and are not of intratelluric origin:—1. The absence of a definite arrangement or orientation among the phenocrysts. 2. Absence of

phenocrysts from the border zones of the granite masses and a gradation peripherally from an interior porphyritic facies into an even-granular granite of coarse texture and of the same mineral and chemical composition. 3. The absence of any evidence of magmatic resorption or corrosion of the phenocrysts. 4. The absence of any flow structure. 5. The abundant inclusions of all the ground mass constituents, a feature very characteristic of these porphyritic granites. A table of the chemical analyses of these rocks accompanies the article.

C. H. W.

Studies for Students. By O. C. FARRINGTON. (*Jour. Geol.*, Vol. IX, pp. 51-65 and 174-190.)

This is a study of meteorites in regard to their chemical and mineralogical composition, their petrographical characteristics, their terrestrial analogies, and to some of the theories relating to their origin.

C. H. W.

Mineralogical Notes. By C. H. WARREN. (*Am. Jour. Sci.*, *161*, 369-373.)

The following minerals are described:—anorthite crystals occuring as a contact mineral in the limestone at Franklin Furnace, N. J.; soda orthoclase crystals of peculiar habit from a phonolyte dike, Cripple Creek, Colo.; iron wolframite crystals from South Dakota; pseudomorphs of wolframite and scheelite from Trumbull, Conn. C. H. W.

A Text-Book of Geology. By A. P. BRIGHAM. D. Appleton & Co. 1901.

This volume is intended for use in secondary schools. It is the latest of the series of *Twentieth Century Text-Books,* and like its predecessors, it is admirably bound and illustrated. Its treatment of the subject is physiographic in standpoint, its style simple, and its language untechnical. Dynamical and structural geology are treated in a manner well suited to explain the essential facts to young students, while at the same time its conceptions are thoroughly up to date. Its treatment of historical geology is over-brief, being merely a summary of life development and of continental evolution. There are excellent pictures of fossils, but the discussion of them brings out little beyond geographic distribution. No attempt is made either at a phylogenetic interpretation of fossils, nor is the method of determining geological horizons by means of them discussed. There is no suggestion of the manner of interpreting past conditions from the paleontological evidence. The term Lower Silurian is retained in preference to the more generally accepted Ordovician.

The book is the best elementary text-book yet produced. As Gilbert said in his Lake Bonneville Monograph, "it is through the study of the phenomena of the latest period that the connection between present processes of change and the products of past changes is established." Mr. Brigham is the first to make in a text-book the true use of physiography, not as a separate department of geology, but as the key to all the others. With biological and stratigraphical explanations from the teacher, the book will be admirably suited to the purpose for which it is intended.

I. H. O.

MONTHLY AUTHOR'S CATALOGUE

OF AMERICAN GEOLOGICAL LITERATURE ARRANGED ALPHABETICALLY.

Bagg, R. M. Jr.

Protozoa. (Md. Geol. Sur., Eocene. pp. 233-257. pls. 62-64. 1901.)

Blake, W. P.

The Caliche of southern Arizona, an example of deposition by the vadose circulation. (Trans. Am. Inst. Min. Eng., Richmond meeting. 7 pp. Feb., 1901.)

Branner, John C.

Annual report of the Geological Survey of Arkansas for 1892. Vol v., with an atlas. The Zinc Lead Region of north Arkansas. pp. 395. 38 pls. Little Rock, 1901.

Case, E. C.

Reptilia. (Md. Geol. Surv., Eocene. pp. 95-97. pls. 10, 11. 1901.)

Clark, W. B. (and G. C. Martin)

Echinodermata. (Md. Geol. Surv., Eocene. p. 232. pl. 61. 1901.)

Clark, W. B. (and G. C. Martin)

Brachiopoda. (Md. Geol. Surv., Eocene. pp. 203-204. pls. 58. 1901.)

Clark, W. B. (and G. C. Martin)

The Eocene deposits of Maryland. (Maryland Geological Survey. Eocene. pp. 19-92, pls. 1-9. 1901.)

Clark, W. B. (and G. C. Martin)

Mollusca. (Md. Geol. Sur., Eocene, pp. 122-202, pl. 17-57. 1901.)

Cragin, F. W.

A study of some Teleosts from the Russel substage of the Platte Cretaceous series. (Col. College Studies. vol. 9, pp. 25-37, 2 plates. May, 1901.)

Daly, R. A.

Marine currents and river deflection. (Science. vol. 13. June 14, 1901. p. 902.)

Eastman, C. R.

Pisces. (Md. Geol. Surv., Eocene. pp. 98-115. pls 12-15. 1901.)

Eckel, E. C.

The Portland cement industry in New York. (Engineering News, May 16, 1901.)

Fisher, O.

Rival theories of Cosmogony. (Am. Jour. Sci., vol. 11, June, 1901. pp. 414-423.)

Gannett, Henry.

Profiles of rivers in the United States. Water Supply and Irrigation papers, No. 44. U. S. Geol. Surv., pp. 100, 11 plates, map. 1901.)

Grabau, A. W.

Guide to the Geology and Paleontology of Niagara Falls and vicinity. Bull. N. Y. State Mus., No. 45, vol. 9, April, 1901.)

Greene, G. K.

Contribution to Indiana Paleontology. Part VII, pls. 20, 21, pp. 50-61. May 23, 1901. New Albany, Ind.)

Hague, Arnold.

Report on the congress of geologists. (Ex. from the report of the Commissioner-general for the United States to the International Universal Exposition, Paris, 1900. Vol. 6, pp. 197-204.)

Hollick, Arthur.

Plantæ. (Md. Geol. Sur., Eocene, pp. 258-260, pl. 64, 1901.)

Keyes, C. R.

Horizons of Arkansas-Indian Territory coals compared with those of other trans-Mississippian coals. (Eng. & Mining Jour., vol. 71, p. 692. June, 1, 1901.)

Knight, W. C. (and E. E. Slosson)

The Dutton, Rattlesnake, Arago, Oil Mountain and Powder River oil fields. (Bull., School of Mines, Wyo., pp. 57, maps. April, 1901.)

Lambe, L. M.

Notes on a turtle from the Cretaceous rocks of Alberta. (Ott. Nat., vol. 15, p. 63. June, 1901.)

Lambe, L. M.

A revision of the Genera and species of Canadian Paleozoic corals. The Madreporaria aporosa and rugosa. (Cont. Can. Paleontology. Vol. 14. Part 2, pp. 97-198, pls. 6-18. Ottawa, 1901.)

Lane, A. C.

Michgan limestones and their uses. (Eng. and Min. Jour. vol. 71, pp. 662 and 693. May 25 and June 1, 1901.)

Martin, G. C. (W. B. Clark and)

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Morganroth, L. C.

The caves of Huntingdon county, Pa. (Eng. and Min. Jour. vol. 71, p. 664. May 25, 1901.)

Newland, D. H.

The serpentine of Manhattan island and vicinity and their accompanying minerals. (Schl. Mines Quart., vol. 22, pp. 307-318. April, 1901.)

Nutting, C. C.

The sea bottom—Its physical conditions and its fauna. (Science, vol. XIII, p. 841. May 31, 1901.)

Pearson, H. W.

Oscillations in the sea-level. III. (Geol. Mag. vol. 8. pp. 253-265. June. 1901.)

Richards, J. W.

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Ries, Heinrich,

Clays and Clay products at the Paris Exposition. 1900. (U. S. Geol. Sur., 21st Annual Report. Part VI (continued) pp. 365-392. 1901.)

Ruedemann, Rudolph

Hudson River beds near Albany and their Taxonomic equivalents. (Bull. N. Y. State Mus., No. 42, vol. 8. pp. 489-587. pls. 1, 2. April. 1901.)

Shattuck, G. B.

The Pleistocene problem of the North Atlantic coastal plain. (Johns Hopkins University circulars, No. 152. May. 1901.)

Ulrich, E. O.

Bryozoa. (Md. Geol. Sur., Eocene, pp. 205-221. pls. 59, 60. 1901.)

Ulrich, E. O.

Arthropoda. (Md. Geol. Surv., Eocene. pp. 116-121, pl. 16. 1901.)

Van Ingen, G.

The Siluric fauna near Batesville, Arkansas. (Schl. Mines Quart., vol. 22, pp. 318-329. April, 1901.)

Vaughan, T. Wayland

Coelenterata. (Md. Geol. Sur., Eocene, pp. 222-231, pl. 16. 1901.)

Wieland, G. R.

Study of some American fossil Cycads, part IV. Microsporangiate Fructification. (Am. Jour. Sci., vol. 11, pp. 423-436. June, 1901.)

Wortman, J. L.

Studies of the Eocene mammalia in the Marsh collection. Peabody Museum, plate 6, pp. 437-450. June, 1901.

PERSONAL AND SCIENTIFIC NEWS.

PROF. H. C. BEELER, of Cambria, Wyo., has been appointed state geologist of Wyoming.

THE NEXT MEETING OF THE INTERNATIONAL MINING CONGRESS will be held at Boise, Idaho.

MR. W. S. GRESLEY, late of Erie, Pa., has returned to England. His address is Derby, Eng.

PROF. J. C. HARTZELL, of the Illinois Wesleyan University, is engaged for the summer with the Indiana Geological Survey.

PROF. C. E. VAN BARNEVELD, of Minneapolis, has recently made a professional trip to Grand Encampment, Wyo., and to Tintic, Utah.

PROF. F. W. SPERR, of the Michigan College of Mines, conducted a class of 35 students in the iron mining district of northern Michigan.

PROF. PAUL GOODE, of the Normal School at Charleston, Ill., has been appointed instructor of geography at the University of Pennsylvania.

THE PROPOSED EXPEDITION TO GREENLAND and Iceland, under the guidance of Dr. R. A. Daly, during the summer of 1901, has been abandoned by him.

CORNELL COLLEGE, IOWA, conferred the degree of LL. D. on Mr. W. J. McGee of the Bureau of Ethnology, Washington at the late Commencement.

DR. BRUCE FINK of Upper Iowa University has been elected professor of geology at Drake University, Des Moines, Iowa.

DR. E. S. RIGGS, of the Field Columbian Museum, is in Wyoming exploring for fossils.

DR. C. H. GORDON is engaged on the Michigan Geological Survey near Port Huron.

PROF. W. M. GREGORY is at work on the same survey in Arenac county.

THE MICHIGAN MINER, published at Saginaw, devoted the issue for July 1, almost exclusively to the coal mining industry of Michigan.

PROF. W. B. SCOTT, of Princeton university, started recently for the Argentine Republic for the purpose of scientific investigations in that country.

PROF. U. S. GRANT, of the Northwestern University, Evanston, Ill., has recently spent several weeks in investigation on the Mesabi range.

DR. A. W. GRABAU has been appointed lecturer in Paleontology at Columbia University. The instructorship in Tufts college, which he has left, is not to be filled for the coming year. Dr. Hollick retains the paleobotany, and will have his headquarters in the Botanic Garden.

DR. WM. B. PHILLIPS has been appointed director of the reorganized Texas geological survey. He will make early examination and report on the petroleum basins of the state and on the trans-Pecos district.

THE MISSOURI SCHOOL OF MINES at Rolla has been considerably strengthened by liberal appropriations by the last state legislature. The scope of the institution will be extended, and new buildings are to be erected.

PROF. I. C. RUSSELL, of the University of Michigan, has been elected state geologist of New Jersey, *vice* J. C. Smock, resigned last year, and has accepted conditionally. He will spend the summer of 1901 in Idaho, in the service of the Unit-

ed States Geological Survey, his address being Mountain Home, Idaho.

Dr. Jaggar and Dr. Palache of Harvard University are engaged during the summer in a survey for folio publication by the Survey, of a portion of the Big Bug mining district near Prescott, Arizona, embraced in a 30' quadrangle.

Dr. A. N. Winchell, of Butte, Mont., will spend the summer visiting the mines of Montana, especially those of gold and silver, in the interest of the Montana School of Mines, and for the purpose of collecting statistics for the United States Geological Survey.

Mr. A. W. G. Wilson and Mr. E. Howe received the degree of doctor of philosophy in geology at Harvard University in June. The former has returned to Canada to engage in geological work, and the latter is connected with Mr. Cross' field party in the United States Geological Survey.

Dr. W. H. Barris, Davenport, Iowa, died at his residence June 10. He was favorably known for his studies of the geology of Davenport and vicinity, and as corresponding secretary of the Davenport Academy of Science. An appropriate sketch of him and his work may be expected in a later number of the Geologist.

The State of Washington established a geological survey by a law passed last winter, appropriating \$5,000 per year, the same to be expended under direction of a geological board, consisting of the governor, lieutenant-governor, the auditor of the state, the president of the state university, and the president of the agricultural college.

According to Prof. A. C. Lane, state geologist of Michigan, in the *Engineering and Mining Journal*, the marls of Michigan are important as a source of suitable material for the manufacture of Portland cement, an industry which is extensive in Michigan, and has served as a subject of statistical inquiry by Prof. I. C. Russell for the United States Geological Survey.

The Geological Survey of South Dakota, under Prof. J. E. Todd, has been put on a more comprehensive and permanent financial basis. His assistants are Prof. C. C. O'Harra, of the School of Mines at Rapid City, in geology; Prof. C. P. Lommen, of the State University at Vermillion, in zoology; and Prof. D. A. Saunders, of the State Agricultural College, Brookings, in botany.

The Montana State School of Mines was provided for in the enabling act of congress which granted the state 100,000 acres of land for such institution. The lands have been mostly located and are leased, producing a revenue to the school. They are classed as agricultural, grazing and timber lands. Their appraised value is \$148,536.02, and the timber is valued

at $221,970. None of these lands have been sold. The buildings erected at Butte were not paid for by the state, but by thirty-year bonds secured by these lands, the state, however, having guaranteed both principal and interest.

MR. H. W. PEARSON, OF DULUTH, recently brought a novel suit against the Great Northern Railroad company It was tried at St. Paul and the question at issue, viz: that of a money consideration of a million and a half of dollars for discovering coal in Montana and Washington, was left undecided by a disagreement of the jury.

Mr. Pearson induced the president of the Great Northern company (Mr. J. J. Hill) to employ him to search for coal along the line of the Great Northern R. R. in 1896, under the guidance of a new hypothesis and law which he (Pearson) claimed to have discovered. The law of Pearson, on examination by competent geologists, proved to be wholly groundless and puerile. It assumed that the earth's crust has never been elevated and depressed, that the ocean had flooded alternately the northern and the southern hemispheres under the disturbing action of ice-caps as suggested by Croll, that such flooding disrupted the then growing forests and carried the *debris* as driftwood against pre-existing highland barriers that were not submerged, that such driftwood, so lodged, was accumulated so as to form coal, that all coal "on earth" could thus be located when once the topography and the oceanic currents were known, that the deposits of Wales, those of Pennsylvania, Ohio etc., were of glacial or post-glacial date, that the Montana and Washington coals, whether Cretaceous or Tertiary, were of the same age as those of Wales and Pennsylvania, that the coals known to have greater elevation were of earlier date than those of lower altitude, that the Crollian submergences were greater in earlier geological (glacial?) time than in the later, that the evidences of such submergences consist in the beaches that are scattered over the country, that the beaches that have been described about glacial lakes in the United States such as the "boulevard beach" at Duluth, and those of lake Agassiz, are ancient ocean beaches, and cotemporary, that the Columbia formation of the Atlantic sea-board, and the Lafayette of the interior, were cotemporary, and due to the same submergence, that the whole science of geology was to be remodeled on this law, forming a "new geology," and that this new geology was simply a reversion to the geological principles that were in vogue a hundred years ago.

Strange to say, this wild, anarchistic notion figured largely in the suit. Be it said, however, to the credit of the intelligence of the jury, the disagreement was due not to the theory but to a difference of opinion as to actual, original discovery of any coal by Pearson, for he had designated certain coal beds

as probably valuable, and the Great Northern Railroad company had entered upon them.

It was shown that the coal designated by Pearson lay in the coal basin that had been described in the tenth United States census report (1880), by W. M. Davis and G. H. Eldridge, and Dr. J. S. Newberry, and by Messrs. Weed and Pirsson, several years before Pearson saw it. It was also shown that a part of the area under contest (the Cottonwood coal area at Stockett) had been examined by the agents of the Montana Central R. R. company and had been by them passed to the Great Northern R. R. company, that other parts had been examined by drilling and had been mapped by the agents of the Sand Coulee Coal company, and that the Great Northern R. R. company had itself decided to enter upon the mining of that area several months before Pearson visited it, and that in a small way, coal had been mined there for 14 years prior to Pearson's visit.

The evidence was clear, the pleading was direct and conclusive, the instructions and charge of the judge were lucid and sufficient, but the jury failed to agree and were discharged. It is said the case will be retried.

Yours truly
George M. Dawson

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GEORGE MERCER DAWSON.

PORTRAIT.

The widespread expressions of deep regret and personal loss following the death of Dr. G. M. Dawsen show that his was no ordinary life. Called away while in his prime, and with a past which gave promise of great achievements yet to come, he has left a blank which will not soon be filled.

Dr. Dawson was the second son of the late Sir J. W Dawson, and was born on the 1st of August, 1849, in Pictou, Nova Scotia. In 1855 his father, who had for some years been acting as Superintendent of Education for Nova Scotia, received the appointment of principal of McGill University, Montreal, and with his family took up his residence there. Instead of the magnificent structures of to-day there were then on the college gounds only two "unfinished and partly ruinous buildings, standing amid a wilderness of excavators' and masons' rubbish, over-grown with weeds and bushes. The grounds were unfenced and pastured at will by herds of cattle, which not only cropped the grass, but browsed on the shrubs, leaving unhurt only one great elm, which still stands as the 'founder's tree,' and a few old oaks and butternut trees."* Surroundings of this kind were not ideal from a university point of view, but made a delightful environment for an intelligent boy. The numerous wild flowers, the birds' nests, the fossil shells in the blue clay, the waste waterway where leaves and twigs became "petrifactions," the lively brook where mimic fleets could be navigated and dams constructed—these and many other ob-

*Fifty years of work in Canada—Autobiographical notes by SIR WILLIAM DAWSON, p. 98.

jects of interest were there, and with the guidance and encouragement of an ever-ready father, the boy's inborn love of nature was daily stimulated and increased.

At ten years of age Dawson entered the Montreal High School, remaining there for one year, and taking a high place in his classes. Subsequently, however, owing to ill-health, his education was carried on for the most part under tutors; and while this system no doubt cut him off from some advantages, it gave him on the other hand wider opportunities for pursuing and mastering subjects which had special attractions for him. Surrounded by books, chemical apparatus, paints and pencils, the days were never too long, and photography, book-binding, painting magic lantern slides, and even cheese-making, afforded him fascinating occupation and amusement. One who knew him well at that time says: "He seemed to absorb knowledge rather than to study, and every new fact or idea acquired was at once put into its place and proper relations in his orderly mind. He was always cheerful, amusing and popular, other boys flocking round him and invariably submitting to his unconscious leadership."

At the age of eighteen Dawson entered McGill College as a partial student, attending lectures on English, chemistry, geology, &c., during the session of 1868-9. While a student at this time he wrote a poem on Jacques Cartier which, while but a boyish effort, was thought very well of by his instructors and gave evidence of his keen love of nature and poetic instinct. The view from the summit of Mount Royal, whither Cartier was conducted by the red men of Hochelaga, is thus described:

"Far on the western river lay,
Like molten gold, the dying day.
Far to the east the waters glide
Till lost in twilight's swelling tide;
While all around, on either hand,
Spread the broad, silent, tree-clad land;
And in the distance far and blue
Long swelling mountains close the view."

The following year Dawson went to London and entered the Royal School of Mines, at that time on Jermyn street. He was fond of the sea, and on this occasion made the passage in a sailing ship, he and another young man being the only passengers. During the voyage he amused himself making

observations on the surface life of the ocean, and the phenomena of phosphorescence. He also studied navigation, under the direction of the captain, and the knowledge then acquired afterwards stood him in good stead when he had to navigate a schooner along the dangerous coast of British Columbia and the Queen Charlotte Islands.

At the School of Mines he took the full course of study, extending over three years, and passed as an associate. At the end of his second year he carried off the Duke of Cornwall's scholarship, given by the Prince of Wales, and on graduation stood first in his class, obtaining the Edward Forbes medal and prize in Palæontology and Natural History, and the Murchison medal in Geology. While at the School of Mines he paid special attention to the study of geology under Ramsay, Huxley, and Etheridge, but also devoted much time to chemistry and metallurgy, under Frankland and Percy respectively, and to mining, under Warrington Smyth. Even in his holidays he was never altogether idle, and during most of the summer of 1871 he was attached to the British Geological Survey, and worked with the late J. Clifton Ward in the Cumberland Lake district. While in England he made many warm friends, with some of whom he corresponded regularly for years afterwards.

On returning to Canada in 1872 he was engaged for some months examining and reporting upon mineral properties in Nova Scotia, and subsequently went to Quebec, where he delivered a course of lectures on chemistry at Morrin College, which was attended by a large and appreciative class. In 1873 he was appointed geologist and botanist to Her Majesty's North American Boundary Commission, which had been constituted to fix the boundary line between British North America and the United States, from the Lake of the Woods to the Rocky mountains, and which had been carrying on its labours for about a year. From early boyhood Dawson had been keenly interested in travel and exploration, and in the Canadian North West he saw a region ready to yield up a rich harvest of discovery. There was the charm of novelty afforded by a well-nigh untrodden field, and the many hardships to be encountered only seemed to lend attractions to the expedition. In those days no Canadian Pacific trains rolled across the continent. Fort Garry, now the fast-growing city of Winnipeg,

with more than 40,000 inhabitants, was then practically the last outpost of civilization, and the great prairies had to be traversed on horseback or on foot, provisions and equipments of every kind being carried in Red river carts, drawn by oxen or ponies, with shaganappy harness. The two years of Dawson's connection with the Boundary Commission were for him years of incessant activity, but the results of his work were of great scientific value. They were embodied in a report addressed to the head of the commission, major (now general) D. R. Cameron, R. A., and published in Montreal in 1875.* The volume, which is now looked upon, as "one of the classics of Canadian geology," is a model of what such reports should be—scientific facts being clearly and succinctly stated and the conclusions logically drawn. The main geological result arrived at was the examination and description of a section over 800 miles in length across the central region of the continent, which had been previously touched upon at a few points only, and in the vicinity of which a space of over 300 miles in longitude had remained even geographically unknown. The report discussed not merely the physical and general geology of the region, and the more detailed characteristics of the various geological formations, but also the capabilities of the country with reference to settlement. The whole edition was long ago distributed, and the volume is now exceedingly scarce and difficult to obtain. While attached to the Boundary Commission Dawson made large collections of natural history specimens, which were forwarded to England and found a home in the British Museum, as well as at Kew and elsewhere. The British Museum obtained no less than seventeen species of mammals not previously represented in its collections.

More or less in connection with the above work were published papers on the "Lignite Formations of the West," the "Occurrence of Foraminifera, Coccoliths, &c., in the Cretaceous Rocks of Manitoba," on "Some Canadian species of Spongillæ," on the "Superficial Geology of the Central Region of North America," on the "Locust Invasion of 1874 in Manitoba and the Northwest Territories," &c.

When the work of the Boundary Commission was brought to a close, Dawson received an appointment on the staff of the Geo-

*Report on the Geology and Resources of the Region in the vicinity of the Forty-ninth Parallel, from the Lake of the Woods to the Rocky Mountains, with lists of Plants and Animals collected and notes on the Fossils.

logical Survey of Canada and began in that connection the long series of explorations of the North West and British Columbia, which brought such great credit to himself and his country. In 1883 he was made an assistant director of the survey, and later, on the retirement of Dr. Selwyn, in 1895, became head of the department, a position which he occupied until the time of his death on the 2d of March last. Throughout his connection with the survey his reports were always of a high order, bearing evidence of his striking powers of observation and deduction. Though thoroughly scientific they always took account of the practical and economic side of geology, and accordingly commanded the attention and confidence of mining capitalists, mine managers and others interested in the development of the mineral resources of the country. When in the field, geology was, of course, the principal object of his investigations, but his wide knowledge of collateral sciences enabled him not merely to collect objects of natural history in an intelligent and discriminating way, and to discuss the flora and faunas of different districts, but also to make important observations on the habits and languages of Indian tribes, to keep continuous meteorological records and to determine latitudes and longitudes. We accordingly find that his reports generally conclude with a series of most valuable appendices, giving special information which could not well be included in the body of the document.

In an elaborate notice of his report on the Queen Charlotte islands, published in Petermann's Mittheilungen (Vol. 27, 1881), the writer after calling attention to the fact that the report dealt not merely with the geology of the islands, but also with their topography, natural history, climate and ethnology, says: "One is amazed at the rich results which he brought back in all these branches, especially as he had only one assistant, Mr. Rankine Dawson, and remained in the islands only two and a half months, from the 12th of June to the end of August, and that in most unfavourably wet weather."

In addition to his field-books proper he generally kept copious journals which contain much interesting information. He had a habit, too, of jotting down notes and sometimes verses on scraps of paper or on the backs of telegraph forms. In the wilds of British Columbia, for example, he writes:

"Contorted beds, of unknown age,
  My weary limbs shall bear,
Perchance a neat synclinal fold
  At night shall be my lair.
Dips I shall take on unnamed streams,
  Or, where the rocks strike, follow
Along the crested mountain ridge,
  Or anticlinal hollow;
Or gently with the hammer stroke
  The slumbering petrifaction,
That for a hundred million years
  Has been debarred from action.

* * * * * * * *

We can fancy him, too, sitting by his lonely camp fire on the shores of the Pacific and penning the following lines:

"To rest on fragrant cedar boughs
  Close by the western ocean's rim,
While in the tops of giant pines
  The live-long night the sea-winds hymn,
And low upon the fretted shore
  The waves beat out the evermore."

Dr. Dawson's gological work was carried on chiefly in the region of the great prairies of the North West and British Columbia, but he was thoroughly informed as to the geology of all parts of the Dominion. In the North West he paid particular attention to the relations of the Cretaceous and Laramie formations; and he discovered the presence in the Cretaceous of southern Alberta of an important series of rocks—the Belly River group—which, he says, "must be considered on the whole as a fresh-water formation. The Kootanie group was also recognized by him as constituting a portion of the early Cretaceous in the Rocky Mountain region. His study of a large area in the interior plateau region of British Columbia established the existence there of a great series of mica-schists and gneisses supposed to be of Archæan age and succeeded by Cambrian, Ordovician, Silurian and Carboniferous strata; while in the Cordilleran region of the same province he described the occurrence of great deposits of contemporaneous volcanic rocks, in various stages of metamorphism. While working in connection with the Boundary Commission also, he studied the crystalline rocks in the Lake of the Woods district, and concluded that a considerable portion of the Huronian formation there consists of metamorphosed volcanic rocks.

He was a careful student of glacial phenomena and according to Dr. G. J. Hinde,* was the first to describe the glacial origin of the Missouri Coteau, and in the interior of British Columbia he has shown that at one period of the Ice age there was a confluent ice-mass, the surface of which stood at a level of 7,000 feet above the sea, and that it must have been at least from 2,000 to 3,000 feet in thickness. He has further established the fact that the movements of the glacier ice in this region were not only to the south and south-east, and through the transverse valley and gaps of the Coast ranges to the ocean, but that it had also a northerly flow, and passed down the valleys of the Pelly and Lewes branches of the Yukon river. Dr. Dawson also maintained that the northern part of the great plains had been submerged, and that their glaciation was in the main due to floating ice.

With regard to his ethnological work we cannot do better than quote from Mr. W. J. McGee's recent appreciative notice in the *American Anthropologist.* Mr. McGee says: "While several of Dr. Dawson's titles and the prefatory remarks in some of his papers imply that his ethnological researches were subsidiary to his geologic work, and while his busy life never afforded opportunity for monographic treatment of Canada's aborigines, it is nevertheless true that he made original observations and records of standard value, that much of his work is still unique, and that his contributions, both personal and indirect, materially enlarged knowledge of our native tribes. It is well within bounds to say, that in addition to his other gifts to knowledge, George M. Dawson was one of Canada's foremost contributors to ethnology, and one of that handful of original observers whose work affords the foundation for scientific knowledge of the North American natives."

Dawson's most notable contribution to ethnology was undoubtedly his memoir on the Haida Indians of the Queen Charlotte islands, but he also published "Notes on the Indian Tribes of the Yukon District and Adjacent Northern Portion of British Columbia," a valuable memoir entitled "Notes and Observations of the Kwakiool People of Vancouver Island," "Notes on the Shuswap People of British Columbia," and other papers.

*Geological Magazine, May, 1897.

When, in 1884, the British Association appointed a committee to study the physical characters, languages and social conditions of the northwestern tribes of Canada, Dr. Dawson was made a member, and it devolved upon him to organize and administer the work of the committee. The work was carried on for years with much success and small money expenditure, and when, in 1896, an Ethnological Survey of Canada was instituted, Dawson was chosen as the head of the survey committee.

Not the least of his services to his country were those in connection with the Behring sea arbitration. He was one of the commissioners and was sent by the British government to the north Pacific ocean to inquire into the conditions of seal life there. Subsequently, his evidence and forcible arguments undoubtedly secured for the British side of the case a much more favourable finding than would otherwise have been obtained. Lord Alverstone (now Lord Chief Justice of England) writing of him in this connection, says: "It is not possible to overrate the services which Dr. Dawson rendered us in the Behring sea arbitration. I consulted him throughout on many questions of difficulty and never found his judgment to fail, and he was one of the most unselfish and charming characters that I ever met. I consider it a great pleasure to have known him." In recognition of his services on the arbitration, Dr. Dawson was made a companion of the Order of St. Michael and St. George (C. M. G.).

He received the degree of D. Sc. from Princeton in 1877, and that of LL.D. from Queen's University in 1890, from McGill University in 1891, and from Toronto University some years later. In 1891 he was awarded the Bigsby gold medal by the Geological Society for his services in the cause of geology, and was also elected a Fellow of the Royal Society. In 1893 he was elected president of the Royal Society of Canada, and in 1897 was president of the geological section of the British Association for the Advancement of Science at the Toronto meeting. In 1897 he was awarded the gold medal of the Royal Geographical Society. Last year he was president of the Geological Society of America, and gave his retiring address at the Albany meeting in December, choosing as his subject "The Geological Record of the

Rocky Mountain Region in Canada." This address was published as a bulletin of the Geological Society of America, and will be prized as giving a summing up of his latest views on some of the problems connected with the complex geology of the west. Many other distinctions, which cannot be enumerated here, fell to his lot, and he had won for himself the esteem and confidence of his fellow-countrymen in all parts of the Dominion. Nowhere was he more beloved than in British Columbia—the province in which he had done so much of his best work, and in which, he sometimes said to the writer, he would like to spend his last days.

After the Toronto meeting of the British Association in 1897, he accompanied a party of the members on a trip across the continent, and all were struck with the warmth of the welcome everywhere accorded to him. "Among the many distinguished visitors," writes the *Victoria Colonist*, "by whose presence Victoria has been honored during the past few days, none holds a higher or more deserved place in the esteem of Canadians than George M. Dawson. In one sense he is the discoverer of Canada, for the Geological Survey, of which he has been the chief, has done more than all other agencies combined to make the potentialities of the Dominion known to the world. He has been engaged in the work so long that he can look back over it with the profound satisfaction which comes from the knowledge that his judgment on points of extreme interest and value has been justified by events. The development of Kootenay, the hydraulic mines of Cariboo, and the gold mines in the Yukon are all foretold in the interesting pages of Dr. Dawson's earlier reports. Therefore, when we find in the voluminous products of his pen, wherein the results of his observations are recorded, anticipations of great mineral development in parts of the province that are as yet unexplored, we feel almost as if such development were guaranteed. A careful observer, a conservative reasoner, a skilful writer, Canada possesses in Dr. Dawson a public servant the value of whose services can never be over-estimated. His name carries authority with it on any subject on which he speaks. That a long career may be before him is the hope of all, for we all know how much that means to the Dominion."

Dr. Dawson was a ready and prolific writer and a brilliant

conversationalist. His quiet humour was infectious, and any dinner party which numbered him among the guests was sure to be a merry one. He seemed to have an inexhaustible fund of information, not merely about his own special lines of work, but covering the widest range of subjects. The marvel was how in his busy life he had acquired so much and such varied knowledge. For one of apparently delicate constitution his powers of enduring prolonged physical exertion were as remarkable as his capacity for continuous mental activity. He was at work at his office until two days before his death, the immediate cause of which was capillary bronchitis. The secret of Dr. Dawson's widespread popularity, no doubt, lay in his downright unselfishness and in his sunny and sympathetic nature.

B. J. H.

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THE PLEISTOCENE PROBLEM OF THE NORTH ATLANTIC COSTAL PLAIN.*

By GEORGE BURBANK SHATTUCK, Baltimore, Md.

In that portion of the Atlantic Coastal Plain which lies between the Raritan and Potomac rivers there is a mantle of loam, sand and gravel covering most of the earlier deposits of the lowland and lapping well up on the Piedmont Plateau. This veneer of unconsolidated deposits has long attracted the attention of explorers and various opinions regarding its relations and structure have been entertained. The attention of the earlier geologists was largely taken up in unravelling the history of the more attractive crystalline and fossil-bearing rocks, and in problems connected most intimately with glaciation, and it was not until Mr. W. J. McGee, formerly of the United States Geological Survey, undertook the study of these superficial deposits that their true relations began to appear. The conclusions on this subject which Mr. McGee has published from time to time during a period of fourteen years may be briefly summarized as follows:

VIEWS OF MR. W. J. M'GEE.

The Lafayette, which is a series of orange-colored loams, sands and gravels, extends up, according to Mr. McGee, from the south and occupies the divides and higher portions of the Coastal Plain of Virginia as far north as Fredericksburg. Distinct from these deposits both in origin and age, is another series of loams, sands and gravels designated by him as the Columbia formation, which fill the valleys of the present streams and mantle the divides between them. This formation is divisible into two phases, fluvial and inter-fluvial. The fluvial phase is composed of deltas which were deposited under water, by those streams in whose valleys they now lie, when the land stood lower than it does today. The inter-fluvial phase is found on the divides and is a littoral deposit made by the waves which beat against the coast at the same time the rivers were building their deltas. The two phases are therefore contemporaneous and grade over into one another. The fluvial phase exhibits a distinct bi-partite division. The upper member consists of a brick-clay and loam, and the lower member is

*From the *Johns Hopkins Circulars*, No. 152, May, 1901.

composed of sand, gravel and huge boulders. The material as a whole, is coarser near the mouths of the gorges where the rivers leave the Piedmont Plateau to pass into the Coastal Plain than it is in the more remote portions of the delta. The inter-fluvial phase possesses no such regularity of bedding, but is indiscriminately composed of clay, sand and gravel largely of local origin. These delta deposits may be identified in all the principle rivers of the Middle Atlantic slope and are particularly well developed in the valleys of the Potomac, Susquehanna and Delaware. Due to the presence of these huge boulders, which were evidently ice-born and indicate a climate much colder than exists today in the same region, as well as to the fact that the Columbia, when traced northward, is found to pass under the terminal moraine, it was concluded that it was Quartenary in age and belonged to the earlier glacial advance. These beds, since their deposition, have been raised and tilted so that they now lie higher in the regions to the north than they do further south. Their present elevation was found to be about 500 feet on the upper Susquehanna and 245 feet at its mouth; 400 feet on the upper Delaware; 145 feet on the Potomac; 125 feet on the Rappahannock; 100 feet on the James and 75 feet on the Roanoke.

Mr. McGee also noted certain well-defined terraces which were distributed over the entire region, and spoke of them as follows:*

"There is a practically continuous series of terraces and beach marks along the fall line from the Roanoke to the terminal moraine—a series of shore lines as distinctive and unmistakable as those circumscribing the valleys of the extinct lakes of the Great Basin, of India, of northern Arabia, or of the partially ice-bound basins of Minnesota, Michigan, Ohio and New York, though they are generally more profoundly modified by erosion, and are frequently concealed by forests. These shore lines embody an easily interpreted record of geologic vicissitude which coincides in every detail with that of the Columbia deposits. They are sometimes carved out of the sub-terrane but are generally built of the loam, sand and gravel of which the Columbia formation consists, and are evidently coeval therewith. Now it is evident that these terraces are water fash-

*Amer. Jour. Sci., Vol. 35, 1888, pp. 387-388.

ioned; but they are not fluvial. * * * The forces concerned in the formation of the Middle Atlantic slope terraces acted horizontally over great distances and with uniform energy for a considerable period, filling depressions, softening contours, and obliterating relief, yet so gently that essential homogeneity of deposit in the horizontal direction and essential uniformity in surface prevails for miles. Only the undulatory and horizontally acting force of waves appears competent to produce so great expanses of uniform surface and constant structure as are exhibited in this region."

A summary of Mr. McGee's views regarding the various land movements as expressed by the present state of the Lafayette and Columbia deposits is as follows:

Post-Chesapeake,	elevation and erosion.
Lafayette (Pliocene?),	depression and deposition.
Post-Lafayette,	elevation and erosion of at least 500 feet; present topography defined.
Early Columbia (Pleistocene),	depression of about 200 feet and deposition.
Post-Early Columbia,	elevation and erosion.
Later Columbia,	depression of about 100 feet and deposition.
Post-Later Columbia,	elevation and erosion.
Present,	depression and deposition.

At the New York meeting of the American Association for the Advancement of Science during the summer of 1900, Mr. McGee took occasion to refer to certain relations of the gravels as developed in the vicinity of Washington. After reviewing briefly the various deposits which occur in that region, he is reported by Mr. J. A. Holmes as making the following statement.*

"In a few localities, especially in the deep cutting in the 200-foot terrace at the end of Sixteenth street, deposits have been observed which fail to fit into this series. This cutting reveals, unconformably beneath the Earlier Columbia and unconformably above the Potomac, a heavy deposit of loam and gravel of a structure, composition, texture and material simulating the Earlier Columbia formation in its normal aspect, save that the materials are more extensively disintegrated and decomposed. The resemblance of the deposit to the Earlier Columbia is such that it might readily be classed with that

*Science, n. s., Vol. xii, 1900, pp. 990-991.

formation if found isolated; but in the Sixteenth street exposure the two deposits are juxtaposed and separated by a well-defined unconformity—*i. e.,* the stratigraphy shows that the deposit in question is materially older than the Earlier Columbia. On comparing the deposit with the Lafayette, as displayed in the nearest exposures of that formation on the west, north and east, it is found to be so different in materials and structure as to demand separation on lithologic grounds; moreover, the deposit is confined to a depression, or amphitheatre, which did not exist at the time of Lafayette deposition, but was produced during the period of rapid degradation accompanying the post-Lafayette uplift; so that it must be discriminated from the Lafayette on the basis of homogeny as well as on that of lithology. The interpretation of the deposit is simple: it is evidently a record of an oscillation during the post-Lafayette and pre-Columbia time, which was not of such amplitude and length as to inscribe itself deeply in the local series of formations and land-forms. On seeking to correlate the deposit with other elements in the coastal-plain series, difficulty is encountered; no corresponding deposits are known either southward or eastward in Virginia and Maryland; the nearest known deposits of corresponding character and position are a part of those found in southern New Jersey, and first grouped by Salisbury under the designation Pensauken, but afterward divided."

Pressure of other duties prevented Mr. McGee from continuing the investigations which he had so happily commenced, and Mr. N. H. Darton, of the United States Geological Survey, took and carried forward the work where Mr. McGee left it.

VIEWS OF MR. N. H. DARTON.

According to Mr. Darton, the Lafayette formation does not end at Fredericksburg, but in disconnected areas, crosses Maryland, Delaware and Pennsylvania, into New Jersey. In this connection he said:* "The northern termination of the deposits was supposed to be near Potomac creek, a few miles north of Fredericksburg; but I have found that while there is a break in its continuity in the region east of the Potomac river, it soon begins again and thence continues northward probably through Maryland, and in attenuated scattered outcrops, through Delaware and into Pennsylvania and New Jersey. It is displayed in the high terraces about Washington, and it caps nearly all

the higher terrace levels of the "western shore" of Maryland northward to the latitude of Baltimore. Still farther northward it is confined to outliers on the divides along the western margin of the coastal-plain region; but at the head of Chesapeake bay it extends farther eastward and, in the high Elk ridge, caps the Cretaceous and Potomac formations over a considerable area."

The Lafayette was also described as continuing down the peninsulas of the Coastal Plain.† In this connection he said: "I have found that the formation extends eastward down the coastal plain peninsulas nearly to Chesapeake bay. These peninsulas consist of remnants of an elevated plain, occupied by a sheet of Lafayette formation, and originally continuous over the entire coastal plain. This plain is inclined gently eastward, its altitude decreasing from 500 feet in the Piedmont region, to from 60 to 80 feet in the vicinity of Chesapeake bay, where it is terminated by an abrupt descent to the low Pleistocene terrace bordering the bay to a width of several miles."

The Columbia of Mr. McGee is found by Mr. Darton to be divisible into an earlier and a later member, which are developed in well-defined terraces, the former lying normally above the latter. The land surfaces upon which the Lafayette and Columbia terraces were deposited has been raised and tilted at various times in such a manner that only in that part of the Coastal Plain which lies near the Piedmont was the normal sequence present, while in that portion bordering on Chesapeake bay the normal sequence was reversed. This state of things was brought about in the following way: At the close of the Lafayette deposition, the surface on which that formation rested was raised and tilted so as to slope eastward toward the sea, and after suffering considerable erosion, it was depressed in such a manner that its eastern portion was submerged while its western margin bordering the Piedmont Plateau remained above water. In the estuaries thus formed and along the coast, the earlier Columbia formation was then deposited. This formation, therefore, built up a terrace below that of the Lafayette in the heads of the estuaries near the Piedmont, but covered up the Lafayette surface where it was submerged to the east. While the deposition of the earlier Columbia was still in prog-

**Bull. Geol. Soc. Amer.*, Vol. ii, 1891, p. 445.
†*Amer. Geol.*, Vol. ix, 1891, p. 181.

ress, the Coastal Plain again tilted so as to bring that portion of it lying to the northeast and against the Piedmont above water, while the southeastern portion was still further depressed. The later Columbia was in its turn deposited in the estuaries beneath the earlier Columbia where the latter had been elevated, and above it where it had been depressed. Consequently the three formations near the Piedmont were developed in separate terraces lying one above the other, the Lafayette at the top, with the earlier Columbia in the middle and the later Columbia at the bottom, while in the eastern submerged portion the formations were not developed in terraces, but in a continual series, with an erosive break between the Lafayette and the earlier Columbia. In this region the sequence ran, beginning at the top, later Columbia, earlier Columbia, and Lafayette.

Mr. Darton has published a number of geologic maps from time to time in which these relations are depicted. In an early map of the Washington region, he included only two formations of gravel, the Lafayette and Columbia, but in a later and revised edition, which is now in the press, and which he has been kind enough to show me, three formations of gravel are portrayed, the earlier and later Columbia and Lafayette, developed in distinct terraces, lying one above the other as described. The Nomini and Fredericksburg folios of the Geologic Atlas of the United States convey his ideas regarding the sequence of gravel in portions of southern Maryland and eastern Virginia. In these publications he distinguishes two gravels lying in distant terraces, the Lafayette above, covering the divides, and the Columbia beneath, occupying the valleys.

VIEWS OF PROFESSOR R. D. SALISBURY.

Professor R. D. Salisbury commenced his work on the detailed survey of the Pliestocene deposits of the Coastal Plain of New Jersey in the summer of 1891. In his first report* he mentions a number of peculiar deposits bearing glaciated boulders which he states were somewhat like till in character. The following is quoted from the Report of the State Geologist of New Jersey for 1891, page 107:

"Drift, closely resembling till and containing striated rock material, occurs on the west side of the Delaware, near Falls-

*Annual Report of the State Geologist of New Jersey for 1891.

ington, three or four miles southwest of Trenton * * * the writer found similar deposits at Bridgeport, Pa., opposite Norristown, still further south. * * * Glaciated boulderets were here taken from clay of such character that, were the locality known to have been covered by ice, its reference to till would be fully warranted. Bridgeport is about 50 miles south of the terminal moraine.

"It is not intended to convey the impression that every region where glaciated stone may be found was necessarily once covered by glacier ice. The possibility of transportation of glaciated material beyond the edge of the ice by water, is distinctly recognized. But it is not believed that water alone, or water-bearing glacially-derived bergs could produce all the results which are here recorded. Neither the structure of the extra-morainic drift, nor its physical make-up, nor its geographic or topographic distribution, is consistent with such a hypothesis.

"At several points in New Jersey south of all the localities thus far mentioned within the state, there are topographic features which are easy of explanation if ice once extended to the region where they occur, but which seem to be very difficult of explanation on any other hypothesis. The features here referred to characterize the region from Washington, Middlesex county, southwest to Fresh ponds and beyond, and also the region east of Trenton, from White Horse to Hamilton square. The topography in these regions is very much like that of a subdued terminal moraine."

In his report for 1892, professor Salisbury discusses at some length the character and origin of the Trenton gravel; he shows very plainly that it was a valley train deposited by the Delaware river from materials washed from the glaciated regions, and states that it was deposited "during that stage of glaciation when the ice edge stood near Belvidere." He then discusses the Yellow Gravel formation of professor Cook and shows that it recorded a most complex history. His conclusions may be summarized as follows:

First. "The time of deposition of the original yellow gravel." This covers the period when the country was sufficiently low to allow the gravel to accumulate on hills which are now nearly 400 feet high, at least south of Matawan. Age pre-Pleistocene.

Second. "An epoch of elevation and extensive erosion. This covers a period when the yellow gravel was raised and the land surface greatly eroded.

Third. "An epoch of depression." This embraces a period when central and southern New Jersey was 150 feet lower than now. This depression is correlated with the first glacial epoch and is also tentatively correlated with the Columbia.

Fourth. "An epoch of elevation and erosion." During this time the land was raised to a greater hight than before and the streams cut deeper valleys than during the early epoch of elevation.

Fifth. "An epoch of slight depression." Correlated tentatively with the last glacial epoch and also was the period when communication was established between Raritan bay and Trenton.

Sixth. "Subsequent elevation." An elevation of 40 to 60 feet followed by the present subsidence.

Professor Salisbury in his report for 1893 divides the yellow gravel for the first time into four well-defined periods: the first and the oldest he calls the Beacon Hill; the second, Pensauken; the third, Jamesburg; and the fourth is left unnamed, but later, in a subsequent publication, is called Cape May.

The Beacon Hill formation appears to be Miocene, and therefore, will not enter further into our discussion of the gravels.

According to professor Salisbury, the Pensauken was deposited in valleys cut out during the post-Beacon Hill elevation. It is considered to be an aqueous formation, and its distribution indicates that the land was submerged 200 feet during its deposition. One of the chief diagnostic features of this formation is the presence of decomposed boulders of gneissic and granitic material found imbedded in its mass. The formation ranges in elevation from 200 feet at Perrineville to 80-00 feet south of Palmyra. The elevation is also regarded as being more in the region of Beacon Hill than elsewhere. At South Amboy its presence is indicated at an elevation of 147 feet.

The name of the formation is derived from Pensauken creek, but the statement is made that the formation is most characteristic near South Amboy, and that the latter locality would have been chosen to typify the formation were it not for its association with the plastic clays.

In the report for 1894 professor Salisbury points out that a submerged trough formerly existed in central New Jersey extending from Raritan bay to Delaware bay, allowing a communication between these two bodies of water and separating southeastern New Jersey from the mainland as an island. In this trough were deposited the Pensauken and Jamesburg formations and the Trenton gravel. Various elevations of the Pensauken are also mentioned in this report. The most noted differences in elevations are the following: at Fish House, the elevation of the Pensauken is stated as 15 feet where it lies immediately under the Fish House clays, the latter being regarded here as post-Pensauken. Nine miles southeast of Fish House, the base of the Pensauken is at an altitude of 150 feet, thus making a rise of 15 feet per mile. Professor Salisbury also reaffirmed the deformation of the Pensauken surface since its deposition. The age of the Pensauken is ascribed to the Lafayette in the following terms: "There can no longer be any doubt that the Pensauken is the equivalent of the Lafayette formation of the south. This conclusion was reached tentatively more than a year since."

In the report for 1895 professor Salisbury points out that the base of the Pensauken formation dips to the southeast in harmony with the Miocene and also inclines toward Delaware river. He also somewhat doubtfully refers the Fish House clays to the Pensauken. The Pensauken formation in the trough extending from Raritan bay to the Delaware river, as well as the Pensauken formation southward along the southeastern bank of the Delaware are here mapped. On this map a large body of gravel found south of a line extending from Philadelphia to Atlantic City is represented as Pensauken, and so stated in the report. A number of sections are given to make clear his conception, in which the profile distinctly shows a marked difference in the elevation of the Pensauken from its lowest position near the Delaware river to its highest altitude in the vicinty of Glassboro and neighboring points. To account for this topographic difference a number of hypotheses are suggested, such as monoclinal folding, faulting, or possibly a bifold division of the Pensauken formation. In this connection he says: "From sections 2, 3 and 5 it would appear that the Pensauken might be a bifold formation." But he still regarded

the whole as Pensauken, for he further says: "Indeed, on any interpretation, the original continuity of the Pensauken across this belt seems certain, for occasional small remnants of it are still found."

In the report for 1896, professor Salisbury no longer regards the Pensauken as being equivalent to the Lafayette, but places it in early glacial time. On the Mt. Pleasant hills he states the Pensauken formation probably lies as high as 178 feet, and suggests that these gravels may be a landward deposit of Pensauken streams.

He also places in the Beacon Hill formation the topographically higher member of those gravels found in the vicinity of Glassboro which, in the previous year, he had regarded as Pensauken. He also publishes a map and a section where this change in classification is recorded. The southward dip of the Pensauken is reaffirmed and the statement is made that the base of the Pensauken formation at times extends down below tide.

In the report for 1897, professor Salisbury publishes a map in which he again changes his classification in southern New Jersey. The high gravels occurring in the vicinity of Glassboro, which he had first mapped in 1895 as Pensauken, and later in 1896, as Beacon Hill, he now places in three distinct formations, namely: Miocene, Beacon Hill, and Bridgeton; the Beacon Hill being younger than the Miocene, and the Bridgeton younger than the Beacon Hill but older than the Pensauken. In this connection he says: "The differentiation of the Bridgeton formation has been long in mind, though data for its sharp definition have been wanting. Even now they cannot be said to be altogether satisfactory. In some places the formation seems not to be clearly separable from the Beacon Hill formation which preceded, while in others it is not easily distinguished from the Pensauken which follows. In other places, on the other hand, it is distinctly separable from the Pensauken, and in still others from the Beacon Hill. The only question, therefore, concerns the integrity of the formation as a whole, and the data at hand do not demonstrate that that part of the formation which seems to be closely allied to the Beacon Hill formation is not really a part of that formation, and that that part which is with difficulty separated from the Pensauken, is not really Pensauken. On the other hand,

these two parts, the one of which seems to have affinities with the Beacon Hill formation and the other with the Pensauken, seem to belong together. * * * *

"In general it (Bridgeton) may be said to contain any sort of material which the Beacon Hill formation contains, and some which it does not. It is therefore most clearly separated from the next older formation by its constitution. But occasionally its constitution closely approaches that of the Beacon Hill formation, and where its topographic relations are at the same time indecisive, its differentiation is uncertain.

"From the Pensauken, on the other hand, it is most clearly separated on topographic grounds, especially in the western part of the state. Here the Bridgeton beds lie at a level distinctly above that of the Pensauken beds, the latter being restricted to the low area west of the Miocene escarpment. The topographic relation of the formations indicates a long interval of erosion between their deposition. * * * *

"Some idea of the former extent of the Bridgeton beds may be gained if all existing remnants of it be conceived to be extended until they merge into one another, bridging the areas intervening between the existing remnants. It is believed that the formation extended much less far north than that which preceded, though the original limits are probably not determinable.

"It is altogether possible that some of the areas mapped as Bridgeton, west of the New Jersey Southern railway, may prove to be Beacon Hill instead, and that some of the areas east of that line may prove to be Pensauken. The distinction in the latter area is based almost wholly on topographic grounds." He again mentions a tilting of the Pensauken formation and correlates the Pensauken with Kansan or Albertan.

A Pleistocene formation much discussed by professor Salisbury in New Jersey is the Jamesburg.

His conclusions regarding the Jamesburg formation may be briefly stated as follows: In the report of 1893, it appears that the Jamesburg was deposited on the eroded surface of the Pensauken. It is aquatic in origin, and the subsidence which made possible its deposition amounted to at least 130 feet. The name is derived from Jamesburg Junction, in Middlesex county. A difficulty is encountered, however, in the absence or obscure-

ness of a shore line for the Jamesburg sea. The material making up the Jamesburg formation is very much like that going to make up the Pensauken. Professor Salisbury states: "In some places the weathering of the latter (Pensauken) might have given rise to the overlying bed, which is here classed as Jamesburg." He states that there is in the Jamesburg an absence of the materials which in the Pensauken are decomposed, such as granites, gneisses and schists, as well as the Triassic shales and sandstones, which are commonly found in the Pensauken. The age of the Pensauken is made equivalent to that of the Columbia or a part of it, for he said: "The Jamesburg is, therefore, but a local name for the Columbia formation, or for a part of it." It is correlated with an early glacial epoch, and Trenton and Trenton Junction are given as excellent localities for the Jamesburg.

In his report for 1894, professor Salisbury regards the Jamesburg as a mantle, covering the country up to 214 feet or more. He considers it corresponding, in a general way to the high-level and low-level Columbia, but that the Columbia of the south is believed to include more than the Jamesburg of New Jersey. The Jamesburg not only covers the bottom, but is found lapping up on the sides of the trough between Raritan bay and the Delaware river with a distribution as wide as that of the Pensauken. It is unconformable on the latter and on older formations. Near Cream Ridge, the Jamesburg is stated as occurring at 214 feet and near Marlton 180 feet.

The Jamesburg is now divided into high-level and low-level Jamesburg. The relations of the high-level Jamesburg are very obscure, the low-level Jamesburg seems somewhat easier to recognize. In regard to the high-level Jamesburg, professor Salisbury says: "The high-level Jamesburg is often very thin. Where it rests on the Pensauken it frequently has the appearance of being but the weathered part of the latter, so that it is often very difficult to distinguish between them on lithological grounds. So true is this that study had been long in progress before the existence of the 'high-level' Jamesburg over the higher areas of the Pensauken was regarded as demonstrated. The great body of facts now in possession, however, has put the existence of this phase of the formation beyond question. This statement is made with full recognition of

the fact that good observers might see scores of sections of Jamesburg and Pensauken, the one over the other, without suspecting a subdivision unless attention was especially directed to the matter. Even then it is probable that nine sections out of ten, or perhaps forty-nine out of fifty, would fail to be convincing on lithological grounds. But the tenth section or the fiftieth is conclusive, and carries the other nine or forty-nine with it."

The Jamesburg is poorly stratified and often contorted as if by lateral pressure. The limits of the high-level Jamesburg are upwards of 214 feet, and the low-level Jamesburg are 45 feet, the latter being deposited in rude terraces. The surface of the Jamesburg is pointed out as being frequently marked with low-ridges and saucer-like depressions. The low-level Jamesburg is considered in part at least younger than the high-level Jamesburg.

In the report for 1895 professor Salisbury states that the Jamesburg formation is very difficult to distinguish, and its existence has been called in question in many places. In this connection he says: "It should perhaps be stated that the existence of the Jamesburg has been called into question at many points. Lithologically it so closely resembles what might be produced from the weathering of the underlying beds, that at many points and over considerable areas, its existence could not be affirmed on the basis of facts there represented. But there are various points, on the other hand, and these widely distributed, where the Jamesburg formation is represented by a thin stratum, which could not by any possibility have been derived from the underlying formations, and the certain presence of the Jamesburg in such places is sufficient to carry the doubtful areas so situated that they cannot have escaped the influence of the agencies which made the deposits about the interpretations of which there is no doubt." He also states that the low areas about the coast are probably low-level Jamesburg, and are equivalent to the low-level Columbia, and in part contemporaneous with the Trenton gravel.

In the report for 1896 under the head of Post-Pensauken submergence, professor Salisbury mentions the 40-foot terraces, and also terraces as high as 200 feet on the Mt. Pleasant hills, as being deposited by streams which emptied into the

sea, when the 40-foot terrace was being formed, and therefore the up-stream portion of the 40-foot terrace.

In 1897 the Cape May formation is defined as developed in terraces running from 30 to 50 feet in hight. It is regarded as part glacial and perhaps in part younger. It is named from Cape May county, New Jersey, where it is typically developed and is regarded as including much of the low-level Jamesburg, and also much of the Trenton gravel.

The high-level Jamesburg (High-Level Loam) is still recognized, but the statement is made that it cannot be mapped. Professor Salisbury suggests that the high-level Jamesburg is a part of the Cape May formation, and represents a brief subsidence of the Coastal Plain of that region, amounting to 200 feet or more, at the close of the last glacial period. He also states that the formation is very hard to distinguish and difficult to be sure of.

A later view was expressed by professor Salisbury on December 28, 1900, when in the course of official correspondence with the Maryland Geological Survey, he said: "You will notice that in the later reports I have not used the word Jamesburg * * * I now regard it as a phase of the Cape May formation."

VIEWS OF THE WRITER.

For a number of field seasons, the author of this paper has been engaged in the investigation of the surficial deposits of Maryland. Reconnoissance work has been extended over the entire Coastal Plain, and a number of counties have been already mapped in detail. In pursuing these investigations, he has made free use of the methods of homogeny, and the correlation of the deposits thus established has necessitated not only the introduction of some changes in the classification and interpretations as suggested by Mr. Darton, but also has shown that the classification adopted by Prof. Salisbury for the New Jersey area is in no measure applicable to Maryland.

The key to the solution of the relations existing between the surficial deposits of Maryland lies almost exclusively, according to the author, in a correct correlation of the various terraces in which they are developed throughout the Coastal Plain. In Maryland, five principal terraces are distinguished, lying one above the other, the oldest occupying the highest and the

youngest, the lowest portions of the region. Beginning with the oldest and enumerating them in succession, we have what the author has designated as the Lafayette, Sunderland, Wicomico, Talbot and Recent. The Recent terrace is the one which the present sea is building.

A correct understanding of the physiographic features of the terraces may be obtained by studying the manner in which this recent terrace is forming. At the present time the waves of the Atlantic ocean and Chesapeake bay are engaged in tearing away the land along their margins and in depositing it on a sub-aqueous platform or terrace. This terrace is everywhere present in a more or less perfect state of development, and may be found not only along the exposed shore, but also passing up the estuaries to their heads. The materials which compose it are extremely variable, depending not only on the detritus directly surrendered to the sea by the land, but also on the currents which sweep along the shore. Along an unbroken coast, then, the material has largely a local character, while near river mouths the terraces are composed of debris contributed from the entire river basin. Where the waves are weak, partially decayed material is torn from the bank and re-deposited practically unharmed on the surface of the terrace, and continues, unchecked, its process of decay.

In addition to building a terrace, the waves of the Atlantic and Chesapeake are cutting a sea cliff along their coast line, the hight of this cliff depending not so much on the force of the breakers as on the relief of the land against which the waves beat. A low coast line yields a low sea cliff and a high coast line the reverse, and the one passes into the other as often and as suddenly as the topography changes, so that as one sails along the shore of the Chesapeake, high cliffs and low depressions are passed in succession. The wave-built terrace and the wave-cut cliff then are constant features along the entire extent of the bay shore, and should be sought for whenever other terrace surfaces are investigated.

In addition to these features, bars, spits and other formations of this character are frequently met with. Were the present coast line to be elevated, the sub-aqueous platform which is now building would appear as a well-defined terrace of variable width with a surface gently sloping toward the water. This

surface would fringe the entire Atlantic and bay shore as well as that of the estuaries. The sea cliff would at first be sharp and easily distinguished, but as ages passed the less conspicuous portions would gradually yield to the leveling influences of erosion, such as soil creep, plant roots, cultivation etc., and might finally disappear altogether. Erosion would also destroy in a large measure the continuity of the formation, but as long as portions of it remained the old surface could be reconstructed and the history of its origin determined.

It was with these features well in mind that the author undertook the investigation of the surficial deposits in Maryland, and it was found that they supplied the necessary clue to their interpretation. Without entering into many details it may be briefly stated that the oldest terrace, the Lafayette, is found as outliers on the eastern edge of the Piedmont plateau from Washington across Maryland and Pennsylvania to New Jersey. The elevation of these deposits varies from about 500 feet behind Washington, as determined by Mr. Darton, to about 300 or 400 feet in the vicinity of Philadelphia, where it has long been known as the Bryn Mawr gravel. Besides these outliers of the Lafayette on the Piedmont plateau, there are others on Elk Neck occupying a lower elevation, and still another and more extensive area on the Coastal Plain immediately southeast of Washington. This area has already been reported by Mr. Darton, but it has been found after careful investigation that in place of extending down the peninsula to the Chesapeake bay, it ends in an abrupt low scarp line, which may be seen in the vicinity of Charlotte Hall, in St. Mary's county, and at numerous other localities. No Lafayette is known to exist, however, on the peninsula at Calvert county. The elevation of the Lafayette at this scarp in southern Maryland is about 270 feet.

The next younger formation, the Sunderland, is extensively developed throughout Prince George's, Charles, St. Mary's and Calvert counties, and numerous outliers exist on other parts of the western shore from Herring Bay to Elkton, but the continuity of the formation in this portion of the state has been destroyed. This formation is developed as an unmistakable terrace butting up against the Piedmont plateau or lapping around the edges of the Lafayette. The scarp line at Charlotte Hall is part of the ancient sea-cliff of the Sunderland sea.

The materials composing it are extremely diverse, and embrace ice-borne boulders, gravel, sand and loam, which change their mutual distribution both vertically and horizontally, after the manner of shore deposits. They are frequently much altered and decayed, and have been derived not only from formations occurring in the immediate vicinity, but also from those found far west in the mountains. In southern Maryland the base of the Sunderland terrace lies at about 90 feet, but rises gradually toward the northwest, until at Charlotte Hall the surface of the bench is found at 170 feet. The name of this formation is derived from the hamlet of Sunderland, situated on the divide, in Calvert county.

After the deposition of this terrace, the country was raised and the Sunderland formation suffered greatly from erosion, but on the submergence of the region, the rivers which had found their way across its surface were transformed into estuaries, and the waves of the Wicomico sea beat on the exposed shores of the Sunderland terrace, and in their turn cut cliffs along its margin. After sufficient time had elapsed to build up a wide terrace, the country was again elevated and subjected to erosion.

What has just been said regarding the materials which enter into the Sunderland formation applies equally well to those composing the Wicomico terrace, except that it possesses perhaps a larger proportion of sand and loam derived from its subterrane. In southern Maryland the base lies at about 40 or 50 feet, and the top, where it borders its ancient sea-cliff at about 90 feet. Wicomico river in St. Mary's and Charles counties suggested the name for this formation.

The Talbot formation is developed as a bench of variable width around the edges of the Wicomico terrace, and frequently separated from it in many places by a low scarp line. Occasionally this scarp, which is the ancient sea-cliff of the Talbot sea, attains a hight of 30 to 40 feet, notably in Kent county, but on the other hand, there are localities where the scarp seems to be entirely lacking, and it is probable that in these places it has been destroyed, since its elevation in the manner described above. The Talbot formation was built up during a slight subsidence which followed the elevation and erosion of the Wicomico terrace. Large areas of the Wicomico and Talbot for-

mations have been mapped on the western shore, but it is on the eastern shore of Maryland that they attain their most extensive development.

Any sort of detritus which enters into the other terraces may be found in the Talbot, but it possesses a greater proportion of loam and a smaller proportion of decayed materials than is found in the other members of the series. It also contains numerous lenses of greenish-blue clay, which frequently carry plant remains and are regarded as swamp deposits, formed in the mouths of ponded streams, and buried by the advancing beach of the Talbot sea. The famous Cornfield Harbor clays, carrying remains of marine and brackish water animals, as well as similar deposits five miles south of Cedar Point, in the same county, are also referred to the Talbot formation. The base of the Talbot terrace is irregular, sometimes lying above tide and sometimes below, but the top, where it borders its sea-cliff, is usually limited by the 45 or 50-foot contour.

A large number of terraces are cut in the Wicomico-Talbot surfaces by the streams along whose borders they lie, and it was not until after many profiles from various and distant regions had been compared that the 45-foot contour was determined to be the one which marked the shore of the Talbot sea. The name of this formation is derived from Talbot county, on the eastern shore of Maryland.

After the deposition of the Talbot terrace, the Coastal Plain was elevated somewhat higher than it is today, and remained in that position long enough to permit the rivers which flowed across it to cut rather deep channels, and its present position indicates a subsidence sufficiently great to drown these rivers and many of their predecessors toward their seaward portions. The Recent terrace is today building along the shore, and cutting its sea-cliff indiscriminately in the Talbot, Wicomico and Sunderland formations.

From the preceding discussion it will be seen then that the classification adopted by the Maryland Geologic Survey recognizes four distinct mapable terraces in Maryland, in place of three as represented by Mr. Darton in the region of Washington, and differs from him in ascribing the formation of the divides of the peninsulas of southern Maryland to a formation younger than that of the Lafayette. Although the Wicomico

surface rises gradually from an elevation of 90 feet in southern Maryland to about 140 feet behind Philadelphia, yet the distribution of the terraces does not seem to the author to indicate the complicated tilting described by Mr. Dalton, but on the contrary points to the following course of events. Miocene elevation and erosion; subsidence and the deposition of the Lafayette formation; elevation and extensive erosion; subsidence and deposition of the Sunderland terrace around the edges of the Lafayette; elevation and erosion; subsidence and deposition of the Wicomico terrace about the margin of the Sunderland; elevation and erosion; depression and deposition of the Talbot about the margin of the Wicomico; elevation and partial erosion of the Talbot; subsidence and the deposition of the Recent terrace about the edges of the Talbot.

It is interesting in looking at a map of these various terraces to see how repeatedly the present estuaries have been transformed from rivers to fjords and back again to rivers, for one may trace the Sunderland, Wicomico and Talbot terraces up the valleys of all the principal streams to the Piedmont plateau.

The unconformity which was described by Mr. McGee in the Sixteenth street cut, to which reference was made earlier, is not regarded by the author as pointing to a period of elevation and a subaerial erosion, but simply as indicating a change of current or possibly freshet conditions and therefore in no way differing from the unconformities in a cross-bedded deposit except in the size of the materials moved. Both the restricted area in which this unconformity is found, as well as its position at the head of the old delta near the mouth of the Potomac gorge where the current must have been constantly changing, point to this conclusion.

A comparison of the section proposed by the author with that formerly suggested by Mr. Darton is as follows:

Darton.	*Shattuck.*		
Later Columbia	Talbot	formation.	Columbia Group.
	Wicomico	"	
Earlier Columbia	Sunderland	"	
Lafayette formation	Lafayette	"	

After a careful study of the surficial deposits in Maryland an attempt was made to correlate them with the formations of New Jersey, belonging to the same period of deposition, as mapped and described by professor Salisbury.

An extended excursion was therefore made in New Jersey in the autumn of 1900, but satisfactory correlations were found impossible. The difficulty encountered did not arise from the lack of contemporaneous deposits but from the fundamentally different classification adopted by the New Jersey Survey. The author found that with the exception of the Lafayette, the terraces were all present and as strikingly developed in New Jersey as in Maryland, and that they were distinguishable not only in the region of Bridgeton but across the entire Coastal Plain to South Amboy. The Maryland classification then, if applied to Delaware and New Jersey, would still indicate Talbot, Wicomico and Sunderland, each developed in a distinct terrace and bearing the same mutual relations which they do further south.

The author was unable to detect any evidence of such a deformation as that described for the Pensauken, but on the contrary the levels at which the various terraces appear were found to agree very closely with those occurring in Maryland.

It was further observed that wide areas composed of reworked marl, falling within the Wicomico formation and building part of its conspicuous terrace, were left unmapped, except where they developed a gravelly phase, when this material was entered as Pensauken.

Whenever the Jamesburg formation was examined it was the belief of the author that the phenomena could be better explained by hypothecating changes in the force and direction of the shore currents than by an appeal to a sudden subsidence of the entire region of more than 200 feet near the close of the Pleistocene, and as sudden an elevation afterward. The author, from his study of the region from the Potomac to the Raritan, is convinced that the Jamesburg materials described are present in each of the Pleistocene formations and evidently represent special physical conditions, not an independent formation.

Without going into more details it is evident that the correlation which the author has employed in Maryland is fundamentally different from that employed by professor Salisbury in New Jersey. A comparison of the two systems of classification would give the following results:

COMPARATIVE TABLE OF MARYLAND AND NEW JERSEY PLEISTOCENE FORMATIONS.

Maryland Sections.	*New Jersey Sections.*
Talbot (lower portions of Later Columbia).	Parts of Cape May and Pensauken.
Wicomico (higher portions of Later Columbia).	Parts of Cape May, Pensauken and possibly Bridgeton.
Sunderland (Earlier Columbia).	Parts of Cape May, Pensauken and Bridgeton.

It is believed by the author that the methods of classification employed in Maryland are the natural ones, and that they will ultimately be found applicable to the determination of the marine Pleistocene deposits of much of the Atlantic Coastal Plain.

EDITORIAL COMMENT.

THE DEPARTMENT OF GEOLOGY IN THE NATIONAL MUSEUM.

Plates X–XIV.

It is proposed to give here a brief account of the Department of Geology in the U. S. National Museum, as condensed mainly from its published handbooks and annual reports. The purport of the paper is to show to what extent the department, as a national institution, is fulfilling its mission in caring for and rendering available to students the materials entrusted to its keeping, and further, in making an intelligent display for the benefit of the public.

The history of the U. S. National Museum may be said to date from the year 1846, when by act of Congress the custody of the National Cabinet of Curiosities, at that time deposited in the Patent Office building, was transferred to the Smithsonian Institution.

This act provided that "All objects of natural history, plants and geological and mineralogical specimens belonging or hereafter to belong to the United States, and which were then in the city of Washington, should be delivered to the Regents of the Smithsonian Institution, and together with new specimens obtained by exchange, donation, or otherwise, should be so arranged and classified as best to facilitate their examination and study." By a subsequent act it is decreed that "all

collections of rocks, minerals, soils, fossils and objects of natural history, archaeology and ethnology, made by the Coast and Interior Survey, the Geological Survey, or other parties of the Government of the United States, when no longer needed for investigations in progress, shall be deposited in the National Museum."

The amount of geological material brought together under these acts prior to 1876 was, though valuable, comparatively small and extremely varied. It consisted mainly of the collection made by Prof. J. D. Dana and his associates during the Wilkes exploring expedition; by the various geologists accompanying the surveys for the Pacific railroads in 1854-5; the surveys west of the 100th meridian under the direction of the engineer corps of the army, and the U. S. Geological Surveys, under direction of Dr. F. V. Hayden. There were also various miscellaneous collections made by surveys under the direction of the general land office.

Prior to 1873 there were no paid assistants whose duty it was to look after the collections. Indeed, Prof. Henry's policy at that time was directly against the utilization of Smithsonian funds for museum purposes. Thus, in one of his reports, he writes that scientific service "can be obtained without charge" or paid "in proportion to the time of engagement."

The natural history collections, including the fossils, were, therefore, worked up by so-called collaborators, several of whom had offices, and some of them sleeping apartments in the Smithsonian building. Amongst the numerous collaborators mentioned are found such names as those of Conrad, Cope, Gabb, Leidy, Lesquereux, Meek and Newberry.

The completion in 1880 of the present museum building afforded an opportunity for expansion and incidental reorganization on a more practical basis. This found expression in the creation of numerous departments and the appointment of salaried officials to take charge of the various collections.

With the appointment of Dr. Geo. W. Hawes to the position of curator of geology and mineralogy, and Dr. C. A. White to that of curator of invertebrate fossils, began the history of the geological department of the museum as an independent department. Dr. Hawes' connection with the museum was, however, too short for his division to become fully organized,

and at the time of his death, which took place at Manitou, Colorado, in 1883, matters were in a state of great confusion, owing to the large amount of material that had accumulated and the extensive census work undertaken but necessarily uncompleted.

The rapid increase of the paleontological collections and the growing demand of the geological survey for space for storage and work-rooms, resulted in early additions to the honorary force, Mr. C. D. Walcott being appointed honorary assistant curator in charge of the paleozoic fossils in 1882, and Mr. L. F. Ward, honorary curator of fossil plants in 1883. In this same year Mr. L. W. Clark was appointed honorary curator of mineralogy.

In 1894 a partial reorganization of the division took place, resulting in placing the entire paleontological collections under the direction of Mr. Walcott, with Mr. Charles Schuchert as assistant curator; Prof. O. C. Marsh of Yale College having nominal charge of the fossil vertebrates.

From the time of the death of Dr. Hawes until 1897 the mineralogical and geological divisions, as a whole, remained without an official head, the assistants, Messrs. F. P. Dewey,* W. S. Yates and G. P. Merrill, retaining charge of their various divisions and reporting directly to the assistant secretary.

At this date a complete reorganization took effect which is still in force and is apparently working very satisfactorily. The entire department, including mineralogy as well as paleontology, is placed in charge of a head curator. In creating the various divisions and sections, regard has been had mainly to convenience in administration and arrangement of material most readily accessible for study and reference. The aim has been to give each officer control of such collections as he may be most interested in and not to hamper him with the care of a great amount of other matter. The general scope of the department in tabular form is given below:

DEPARTMENT OF GEOLOGY:

George P. Merrill, Head Curator.

(a) Division of Physical and Chemical Geology, (Systematic and Applied):

George P. Merrill, Curator.

W. H. Newhall, Aid.

*Mr. Dewey resigned in 1889.

(b) Division of Mineralogy:
F. W. Clarke, Honorary Curator.
Wirt Tassin, Assistant Curator.
Dr. L. T. Chamberlain, Honorary Custodian of Gems and Precious Stones.

(c) Division of Stratigraphic Paleontology:
Charles D. Walcott, Honorary Curator.
Charles Schuchert, Assistant Curator.

(1) Section of Vertebrate Fossils:
F. A. Lucas, Acting Curator.

(2) Section of Invertebrate Fossils:
Paleozoic: Chas. Schuchert, Custodian; Geo. H. Girty, Custodian of Carboniferous Collections.
Mesozoic: T. W. Stanton, Custodian.
Cenozoic: W. H. Dall, Associate Curator.
Chas A. White, Honorary Associate in Paleontology.

(3) Section of Paleo-botany:
A. C. Peale, Aid in Charge of Collections.
Lester F. Ward, Associate Curator.
F. H. Knowlton, Custodian of Mesozoic Plants.
David White, Custodian of Paleozoic Plants.

Considered in the order above given, the following descriptive matter, compiled from the handbooks and annual reports of the various curators and assistant curators, will be found of interest.

Division of Physical and Chemical Geology, Systematic and Applied. In this division consideration is given to the bringing together, and so far as is practicable, preparing an exhibition of materials bearing upon the history of the earth in its cosmical aspect and illustrative of its composition and structure. Lack of space has prevented the carrying out of an ideal exhibition series, and from year to year it has become necessary to withdraw some of the smaller and less striking exhibits and install in their places materials of more general interest. It is not to be understood, however, that the exhibits that are withdrawn are rejected. They are simply placed in storage, where they may be available for reference, or for exhibition when space shall be provided.

The more important exhibits found here and which are of a nature, either on account of their size or rarity, as to seldom find their way into the smaller museums, are a cluster of basaltic columns in the position in which they were formed (see pl. XIV); a large series of specimens illustrating (1) limestone caverns and associated phenomena (see pl. XI); (2) glaciers

and glaciation; (3) volcanoes and volcanic activity; (4) concretionary structures in crystalline and fragmental rocks (see pl. XII), and (5) faults, folds and other phenomena produced by purely dynamic agencies. In addition to these there is a systematic series of rocks and fossils from the various geological horizons of America.

Some of the more striking of the exhibits in this division are shown in the accompanying illustrations. The collections in this section now occupy a floor space of but 50 by 90 feet.

At the time Dr. Hawes entered upon his duties as curator, he also assumed charge of that branch of the tenth census relating to the quarry industry of the United States. To this work he gave almost his entire attention, and although his labors were unfortunately cut short when little more than a beginning had been made, yet the carrying out of the work as planned resulted in the accumulation of several thousand samples of building and ornamental stones, and the large mass of information relating thereto which appeared in volume X of the reports of the tenth census. Out of the materials thus collected upwards of 3,000 specimens were dressed in the form of four inch cubes for exhibition purposes. These have been described by the present head (then assistant) curator in a handbook of some 370 pages, published in connection with the annual report for 1886. Another important collection is a series of metallic ores and non-metallic minerals arranged on a geographic basis, i. e., by states, and a large series of economic materials arranged on one of the recently completed galleries in the southwest court, a section of which is shown in plate I. This last collection alone comprises upwards of 4,000 specimens, the non-metallic portion of which has been described in the report of the National Museum for 1889, just issued.

Space has also been devoted to collections illustrating the methods of treatment of ores, and reference should be made to an important series illustrating the extraction of gold, silver, lead, copper, zinc, iron and the manufacture of steel. This series, together with a descriptive catalogue of the systematic collections in economic geology, was described in Bulletin No. 42 of the National Museum, published in 1891. These series are very complete and illustrate all stages of the process from the crude ores to the finished product, with also the fuel, fluxes,

and various by-products. They are accompanied by engravings (plates from published handbooks) showing mines, mills and furnaces from which the various samples were taken. Each collection begins with a series of the ore-bearing minerals. This is followed by a series of the ores in which the ore mineral is evident to the eye, and this, in turn, by selected samples of the ores as mined, and in which, as is often the case, the ore-bearing mineral is wholly inconspicuous.

The economic collection is somewhat exceptional on account of the prominence given to what are classed as the non-metallic minerals (i. e., minerals not used as ores of metals). There are thus exhibited, grouped by usage and kinds, very complete series of natural pigments, abrasives, salts used in fertilizer and chemical manufacture, sulphur and sulphur ores, clays, limes and cements, diatomaceous earth and tripoli, asbestos, both crude and manufactured, mica, fluxes used in metallurgical operations, coals and other hydro-carbon compounds, etc. Some prominence is given to the rarer earths and minerals which are now coming into more general use, as monazite, cerite, zircon, spodumene and other lithia minerals, celestite, uranium compounds etc. These collections are described in detail in the handbook above mentioned, from which plate I of this article is taken. A feature which has thus far been largely overlooked in collections of this nature, is a consideration of water as a mineral and its exhibit among other economic mineral products. One case is given up to a display of this nature, selected to show kinds and geographic distribution in the United States.

Another collection which will bear special reference is that of crude petroleum. This comprises upwards of 300 samples, some of which are of historical interest, as a sample, in the original package, of the "medicinal oil" from Little Rennox creek, Kentucky, put up in 1856. The collection is arranged to show (1) variations in specific gravity and (2) color, (3) geological horizons, and (4) geographical distribution. A small series of distillation products is also shown, though here, as in other instances, the strictly technological side is from necessity, largely omitted. This collection is accompanied by maps showing the known distribution of petroleum and bituminous products throughout the world, and a small collection of oil sands and bitumen-bearing rocks.

These economic collections are the most systematic of their kind in the country, and in many respects the most complete and systematic of any public museum in the world.

By law, as noted above, the museum is the repository of all mineralogical and geological material collected by the various departments of the government, when the various investigations for which they were made are completed. This results in bringing together a vast amount of material, worthy of preservation, in fact, of the very greatest scientific value for reference and study purposes, but quite unsuited for exhibition. Materials of this nature are classified by kinds or by areas, according to the conditions under which they have been studied, and put away in drawers in storage cases, where they may be available whenever desired. Among the more important collections, which may be mentioned here, are those made by the early Hayden and Wheeler surveys; the tenth census iron ore series described by Pumpelly; the collections of the 40th parallel survey, including the lithological series described by Zirkel; the Washoe collections representing the work done by G. F. Becker and colleagues in the Washoe district and Comstock lode, Nevada, the results of which were published in Monograph 3 of the U. S. Geological Survey; the rocks of the Eureka district, as described by Hague and Iddings, in monograph 20, U. S. Geological Survey; the Pacific coast quicksilver collections, comprising several hundred specimens as described by G. F. Becker and colleagues in monograph 13 of the U. S. Geological Survey; the Leadville collection, comprising nearly four hundred eruptive, sedimentary and metamorphic rocks and ores collected and studied by Messrs. S. F. Emmons and Whitman Cross, and described in monograph 12 of the U. S. Geological Survey. It also includes type series of the rocks described by the survey petrographers—as those of the Silver Cliff and Ten Mile districts, Colorado—and representative series of rocks of the various published quadrangles.

The mineral collection is evidently very systematic and contains much material worthy of special mention. Among the more noteworthy specimens is a fine large octahedron of gold and a cluster of crystallized gold showing nearly 20 more or less perfect octahedra. The collection also contains type specimens of warrenite, hanksite, spangolite, lawsonite, zunyite, and

guitermaneite; also the complete series of uranium minerals used in investigations by Hillebrand which led to the discovery of nitrogen in uraninite and indirectly to the discovery of argon.

Among the more notable suites in the exhibition series may be mentioned a magnificent collection of Copper Queen azurites, Siberian topazes, and twinned calcites containing arborescent copper from the Lake Superior region. The collection is rich in specimens from the older Pennsylvania localities, as for example, a magnificent series of brucites mainly from the collections of Isaac Lea and Joseph Leidy; also a series of zaratites on chromite from the old Wood mine, Texas, Lancaster county, Pennsylvania.

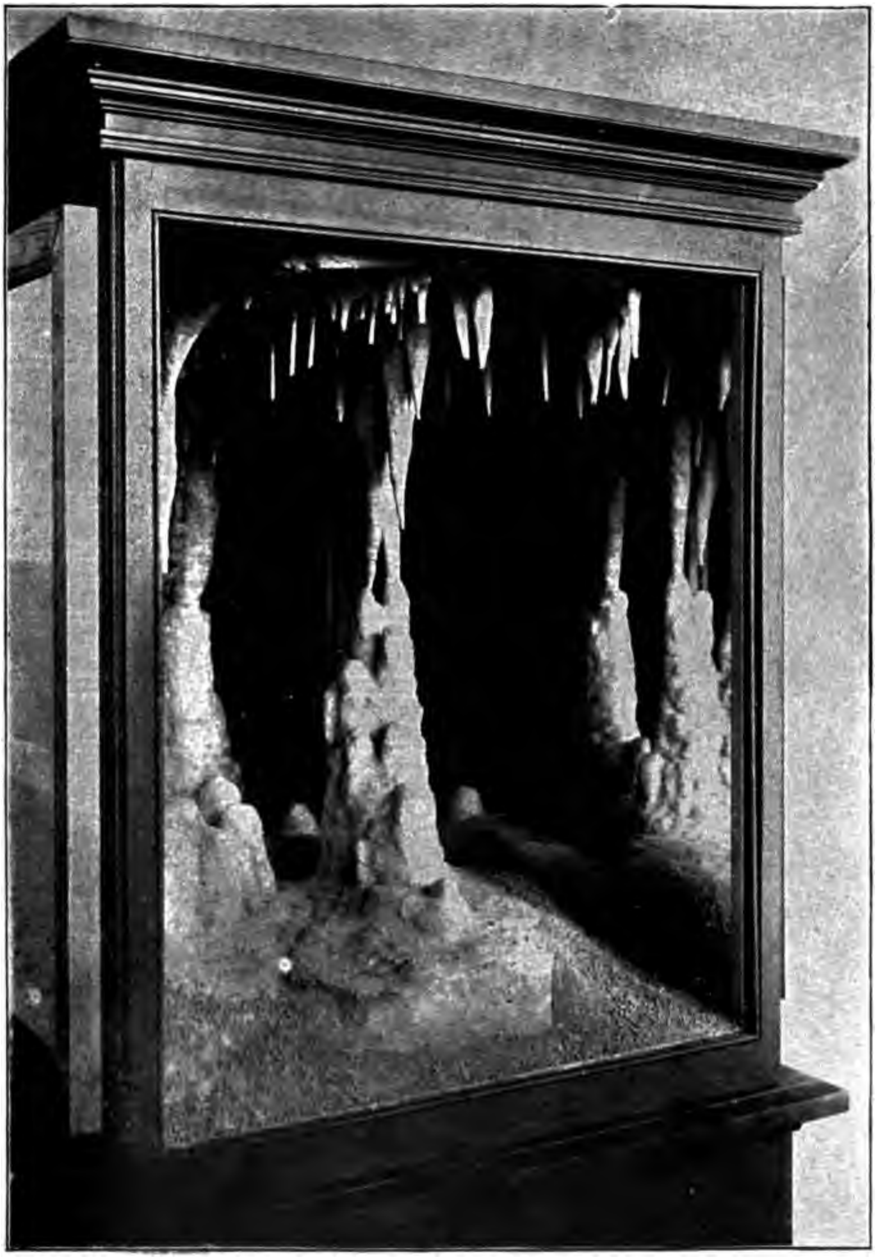
Worthy of particular note here is a recent accession from Dr. C. U. Shepard of Summerville, South Carolina, comprising the entire private collection of the late Prof. Chas. U. Shepard. This is especially valuable, since it contains Dr. Shepard's type materials and specimens, from which drawings were made for purpose of illustration in the earlier works on mineralogy. It also contains fine examples from localities now inaccessible or exhausted.

The large block of native copper described by Schoolcraft in his narrative of explorations of the source of the Mississippi in 1820, from Ontonagon county, Michigan, is displayed in this section of the department.

A comparative series, designed primarily for students of mineralogy, and which illustrates various characteristics or properties of minerals, containing some 2,800 specimens, is arranged along the west side of the hall. The gem collection, which since the recent generous accessions to the collections in the American Museum in New York, now ranks as second of the public collections in the country, owes its origin to an exhibit of precious stones made by the National Museum at the Cincinnati and New Orleans expositions in 1884 and 1885. In 1894 the museum secured by purchase the Leidy collections of gems and later, by request, the important collection of Dr. Isaac Lea. Since that time the growth has been rapid and systematic, owing largely to the influence of the honorary custodian, Dr. L. T. Chamberlain. Particular effort is made to illustrate the gem resources of the United States. A large, rich green,

SHOWING INSTALLATION OF ECONOMIC MATERIALS, ON GALLERY IN NATIONAL MUSEUM.

(*From Ann. Rep. U. S. Nat. Museum for 1899.*)



SECTION FROM MARENGO CAVE, INDIANA, AS INSTALLED IN THE NATIONAL MUSEUM.

(*From Report of U. S. Nat. Museum for 1893.*)

FIG. 3. CONCRETIONARY STRUCTURES.

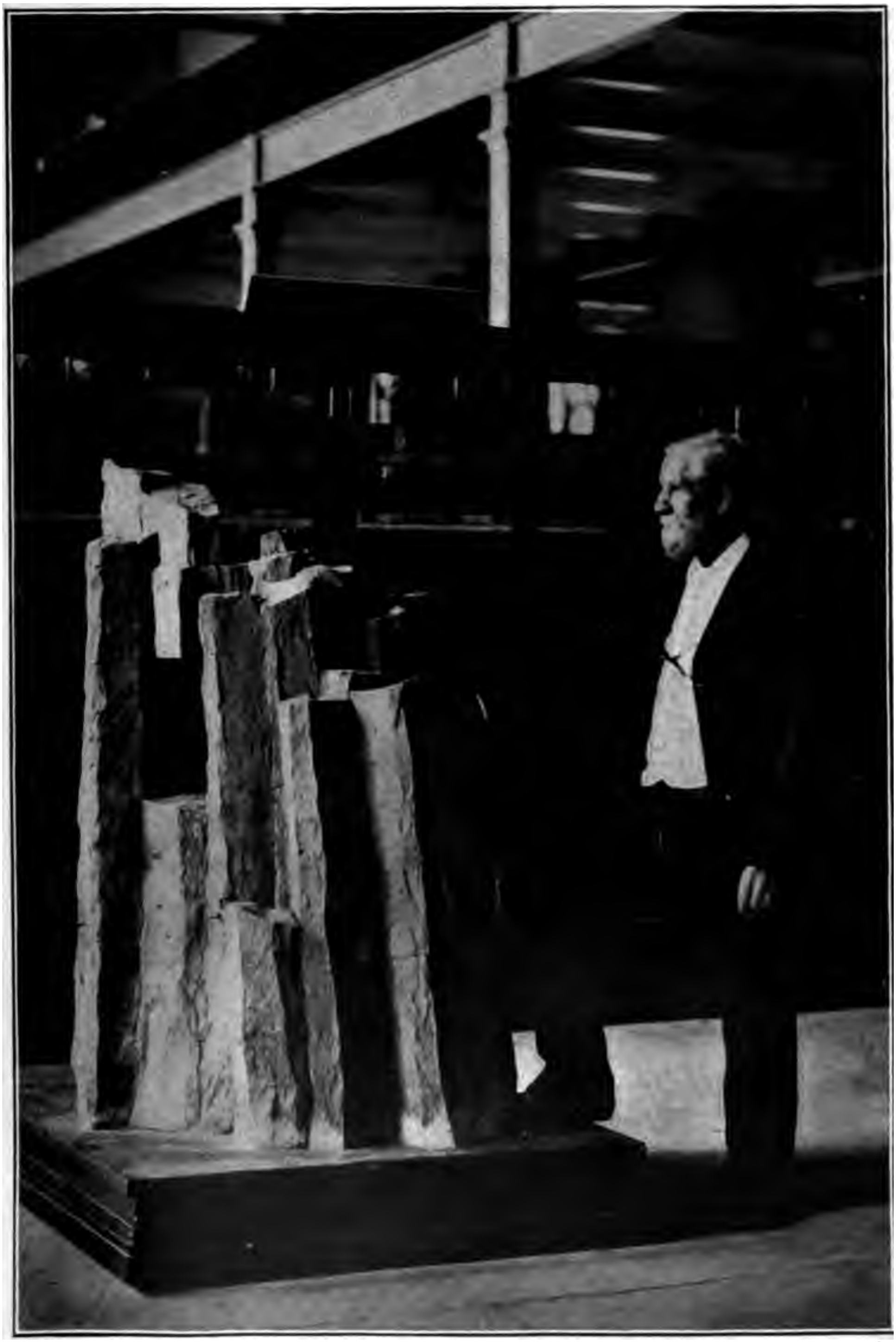


FIG. 1. CLUSTER OF BASALTIC COLUMNS.

brilliant cut tourmaline, weighing 57½ carats, from Paris, Maine, is noteworthy. There is also a fine, claret-red tourmaline, weighing 17½ carats, from the same locality.

There are also sapphires and rubies from the Jenks' mine, Macon county, North Carolina, including the dark-brown, asteriated form described by Kunz in the transactions of the New York Academy of Sciences in 1883. The recently discovered Montana sapphire locality is represented by a beautiful suite of specimens, characteristic for their remarkable lustre and marked dichroism.

The beryl series comprises what is supposed to be the largest emerald crystal found in North America, and a fine series of cut emeralds and beryls from North Carolina, as well as a fifteen-carat, cut stone from the quarries at Portland, Connecticut. This last is of a rich, deep aquamarine color, fairly rivaling the best Brazilian stones.

The collection also contains a fairly satisfactory series of cut hiddenites from Alexander county, North Carolina; a cinnamon-colored, fifteen-carat, cut topaz from Pike's peak, Colorado, and a selected series of cut turquoises from New Mexico, the gift of the American Turquoise Mining Co.

The meteorite collection comprises, all told, some 752 specimens representing 329 distinct falls or finds. The more notable specimens in this collection are the historical Tucson or ring meteoric iron, the Allegan stony meteorite which fell in Michigan in July, 1899, and the unique Bishopville stone, discovered in 1843. A special effort is made to secure representatives of all American falls and but little attention is paid to minute fragments too small for study.

Section of Invertebrate Fossils. The paleontological collection, like other of the collections in the geological department, consisted at first very largely of material brought in by the government exploring expeditions. Incidentally many small lots were presented or received in exchange and a few purchased. Other additions have since been made through the governmental exhibits in which this section has taken part. A valuable collection of fossil insects and a few vertebrates formed a part of the Lacoe collection mentioned elsewhere. Perhaps the most important collection of invertebrates that has come to the section by bequest is what is known as the I. H. Harris collection

of Lower Silurian invertebrates from southern Ohio. This contains over 20,000 specimens and is referred to in the report for 1898 as one of the finest ever made from the rocks of the Cincinnati group, being particularly rich in starfishes, crinoids, and trilobites, including numerous type specimens.

During the past 20 years the section has naturally been very greatly enriched by materials turned over by the U. S. Geological Survey. How rapid has been the growth of these collections is shown by the record books, which, in 1859, had less than one thousand entries; while, in 1898 alone, more than 33,000 specimens were added and the total accumulation is estimated at some 350,000 specimens, very many of which are, of course, duplicates.

No inconsiderable part of the value of these collections lies in their type specimens, or those which have been illustrated in the various works on paleontology. It is stated that there are, all told, something like 4,575 lots which have been thus described and figured.

The exhibition space for this section is limited to 300 running feet of space on one of the galleries. The exhibits are divided into (1) a historical collection, (2) a synoptic collection, and several minor series illustrating development of the faunas of particular areas. The great bulk of the invertebrate collections are, however, stored in drawers constituting what is known as the reserve series. The paleozoic collection is very rich in Cambrian and Ordovician types, a condition due largely to the efforts of Mr. Walcott and the I. H. Harris bequest. The Devonian and Carboniferous faunas are, however, only fairly well represented and the Silurian series is reported as being comparatively weak. The entire paleozoic series, aside from that portion on exhibition, is now stored in something like 1,300 drawers. The mesozoic collection is rich in materials from the southern and western states, but weak in specimens from the Atlantic border. The Tertiary collection is exceedingly rich.

Section of Vertebrate Paleontology.—Prior to 1898 this section, though containing many of the types of Cope, Leidy and Newberry, made very little display, the specimens collected by the earlier geologists and explorers being almost invariably of a fragmentary nature.

In 1898 Prof. O. C. Marsh, then acting as an honorary curator of vertebrate fossils, transferred a portion of the collection made by him under the auspices of the U. S. Geological Survey, to the museum, and the history of the section might well begin with this date. After the death of Prof. Marsh the entire collection belonging to the government was transferred to the museum, as has been noted in a prevous number of this journal.* As is there stated, the actual number of specimens represented in the collection cannot be stated, since they range from minute teeth of fossil mammals to individual specimens weighing from 500 to 2,000 pounds each. The collections are rich in Dinosauria, especially in Triceratops and Stegosaurus, while the series of Titanotherium skulls is probably the best in existence, containing more than fifty complete examples already cleaned and a number in the rough.

Among the specimens thus transferred are the types of forty or more species, including dinosaurs and Jurassic, Cretaceous and Tertiary mammals, the more important of which are as follows:

DINOSAURS.

Labrosaurus ferox,
Camptosaurus nanus,
Triceratops calicornis,
Triceratops Obtusus,
Triceratops elatus,
Ceratops montanus,
Ceratops alticornis,
Pleurococlus nanus,
Stegosaurus stenops,
Stegosaurus sulcatus,

CROCIDILES.

Rhytidon rostratus.

SNAKES.

Coniophis precedens.

JURASSIC MAMMALS.

Paurodon valens,
Menacodon rarus,
Ennacdon affinis,
Ennacdon crassus,
Laodon venustus.

CRETACEOUS MAMMALS.

Priconodon crassus,
Crimolodon agilis,
Telacodon præstans,
Oracodon cenulus,
Allacodon fortis,
Batodon tenuis.

TERTIARY MAMMALS.

Titanotherium dispar,
Trigonias obsorni.

The work of cleaning and mounting vertebrate fossils is slow and expensive and it will be many years before the museum, at the present rates, can exhibit a series of these interesting remains which will be at all satisfactory. A beginning has, however, been made.

* AMERICAN GEOLOGIST, March, 1900, pp. 171-173.

The department has for many years been the depository of miscellaneous collections of fossil plants made by various exploring expeditions and geological surveys, but it was not until 1892 that the paleobotanical series became of sufficient importance to merit consideration among the great collections of the world. In this year, the late Mr. R. D. Lacoe gave to the government his entire collection of fossil plants, a collection tne value of which has been partially made known to the scientific world through Lesquereux's Coal Flora, of the second geological survey of Pennsylvania. This collection is estimated to contain, all told, not less than 100,000 specimens, of which 575 are original types.

In addition, there are the collections described in Lesquereux's Cretaceous and Tertiary Flora, vol. VIII. of the report of the Hayden Survey, and his Flora of the Dakota group, monograph 17 of the present U. S. Geological Survey, and in Fontaine's Mesozoic Flora of North America, monographs 6 and 15, U. S. Geological Survey; Newberry's Later Extinct Flora of North America, monograph 35, U. S. Geological Survey; White's Fossil Flora of the Lower Coal Measures, monograph 37, U. S. Geological Survey, and others of less importance. It is easy to see, therefore, that the collection is by far the largest and most valuable of its kind in America, and perhaps in the world. It contains altogether not less than 2,000 types and figured specimens.

The view here given (plate XIII) from the annual report of the Museum for 1900, shows the gallery of the Museum devoted to the storage of the study series of fossil plants. The section has here some 1,900 drawers, giving an area of 10,000 square feet of storage space. The table cases around the outer edge of the gallery serve as convenient tables for the laying out of material for study.

The question as to what extent it is proposed to carry the exhibition series in the Museum is an important one. The present feeling on the part of the officers of the various departments, is that a practical limit is very quickly reached. A comparatively small number of well-selected, well-preserved, typical forms, properly labeled and so installed as to attract attention and at the same time convey an idea, are recognized as of greater value than dozens of specimens of poorer materials

displayed in a less satisfactory manner. In fact, unless each succeeding specimen illustrates some new feature, the smaller the display the better. But, how to so display a specimen as to get the maximum value, is a question with which the curators of every museum are still struggling. Color of case interiors, direction of light, character of label and many minor points have to be considered. In the department of geology the prevailing color for case interiors is a warm cream tint. Years of experience have shown this to give most general satisfaction, when its non-fading character and the varying color of the specimens are taken into consideration. Labels are brief and printed with heavy-faced black type on gray green board. This color is not all that might be desired from a purely æsthetic standpoint, but it has been selected as affording a label that is legible and non-fading; the first essentials of a label are considered legibility and conciseness of statement. In the early history of the department, labels were much larger than at present. It was found, however, that not merely would it prove to be a practical impossibility to label the entire collection as fully as proposed, but that the public did not demand such. Certain striking specimens of large size, or of peculiar interest for other reasons, do demand full explanatory labels. In the systematic series it has, however, been found that a brief label, giving name and locality, best serves the purpose, additional information being given in the case label and in books of reference placed upon the tables in the halls. As a rule, no specimen such as cannot be replaced is put upon exhibition, if more liable to injury or deterioration there than in the drawers of the reserve series. Nor is a specimen necessarily considered as withdrawn from the study series by being placed upon exhibition.

The question of getting a maximum number of specimens into a case, with a minimum amount of interference or shadow, has been quite satisfactorily solved, so far as the section of vertebrate fossils is concerned, by the means shown in plate [illegible]. As will be noted, shelving is done away with, excepting that afforded by the bottom of the case and two narrow shelves at the top, for large and heavy materials which are often out of classification as compared with the rest of the exhibit. The fossils are here cemented to encaustic tiles of standard

sizes in units of four inches width, which in their steeply inclined position are prevented from falling forward through sudden jar by an overlapping edge of wood at the top. By an actual trial, it has been found that though an apparently wasteful method of installation, so far as space is concerned, more material can be put into a case than when the ordinary horizontal or sloping shelf is used, and moreover, the view of one specimen is never obscured by one in front, or shadowed from above. The possibly objectionable features thus far discovered, are that it limits the size and weight of the specimen exhibited and necessitates the cementing of the samples to the tiles. The first mentioned objection has proven of little moment, space for the larger forms being found at the bottom, or on the narrow shelves; while the second is avoided by not including in the series materials that would be injured, or whose value would be in any way impaired by the cementing process. These tiles are of a light buff color, non-fading, and as they never warp, as does wood, are found very satisfactory; and when all sizes are taken into consideration, no more expensive than is the latter material.

This method of installation, so far as we know, is unique among American museums, though, excepting in the matter of kind of tiles used, it resembles in a general way the custom followed with certain collections in the museums of Prague and Vienna.

It need scarcely be said that a museum dependent so largely upon legacies from other departments of the government or gifts from private individuals as is the National Museum, has developed in a very unsymmetrical manner. Such a museum has been compared to a book, with here and there a word, line, or page, or perhaps whole chapters missing. It is for those in charge then to fill the gaps—to round out their collections, by field trips, by soliciting gifts, or by purchase. But, inasmuch as the National Museum has no endowment and is dependent upon annual appropriations from congress, the administration finds itself in the apparently somewhat inconsistent position of at the same time asking for funds to provide more space, and also for the purchase and care of more material.

As appears from the reports, the functions of the officials are not limited to the care of the collections and the building

up of exhibits in the museum. Since the Centennial Exhibition of 1876, few years have passed in which the museum as a whole, or some of its departments, has not been called upon to prepare for public expositions of greater or less magnitude. In the earlier of these the department of geology took no part, but beginning with the expositions of Louisville and Cincinnati in 1884, it has contributed to those of New Orleans in 1885, Minneapolis in 1887, Cincinnati and Marietta in 1888, Chicago in 1893, Atlanta in 1895, Nashville in 1897, Omaha in 1898, and is now preparing for the Pan-American exposition at Buffalo in 1901, with a more than reasonable prospect of being called upon for that of St. Louis in 1903.

This carrying on of exhibition work outside of Washington has affected the department in many ways. "Probably no other great permanent museum of the world has had constantly before it the problem of guarding its treasures from deterioration, and at the same time transporting portions of them hundreds and thousands of miles and there displaying them under such unfavorable conditions as must exist in temporary expositions. The advantages lie in the direction of making the work of the museum known to the people at large, and in the opportunities offered by direct appropriation for purchase or for paying traveling expenses, for securing new material to fill out deficiencies in the existing collections. The disadvantage lies in damage done to objects in the collection by breakage, or perhaps actual loss, and in the interruption of the regular museum work and the dissipation of the energies of the scientific officers and employes."

The work of preparing for these expositions is apparently not the only work of an ultra museum nature which its officials are expected to perform. From the reports for 1895 and 1896 we learn that "It has always been the policy of the museum to examine, free of charge, specimens transmitted to the museum for determination, no matter from whom or from what locality. The curator of each department in the museum is expected to be an authority in his own line of work, and the knowledge of the whole staff of experts is thus placed, without cost, at the service of every citizen." (p. 45.)

"It is much to be regretted that many specialists, intent chiefly upon the study of certain scientific problems in which

they individually are absorbed, are disposed to neglect the claims of the educated public to the enjoyment and instruction which museums afford. They do not hesitate to say that scientific museums should be administered for the benefit solely of persons engaged in research. Such men would find no welcome among us."

The privilege above noted has been appreciated, as is shown by the large number of packages received daily with requests for identification. "Since the museum was opened in 1881, not less than 6,000 persons have taken advantage of this privilege, and not a day passes without receiving similar requests." As may readily be imagined, very many requests for assays and analyses of material of supposed economic value are received. The museum has, however, no facilities for this work.

The National Museum is not organized primarily as a bureau of research, but rather as a museum of record, a place for the preservation of the types of past investigations. The first duty of its officials relates, then, to the care of the collections. The amount of original work that is put out from year to year may not, therefore, be as great or, possibly, in all cases of as high grade as would be the case under more favorable circumstances. That a large amount of good work is nevertheless, being done, is self-evident.

Materials donated to the museum or deposited for preservation must, of course, be retained indefinitely, unless an agreement is made to the contrary. Nevertheless, by one means or another—often through the direct personal efforts of the curators—a large amount of duplicate material is acquired, which, as occasion offers, is made up into sets and distributed under congressional endorsement to schools and colleges, or sent out by way of exchange. It is calculated that, from the department of geology alone, there have been thus sent out during the past ten years not less than 30,000 specimens of rocks, ores, minerals and fossils.

The seriously crowded condition of the museum exhibition halls is a subject of chronic complaint in all of the reports. Confining our attention to the geological department, it is evident that the present exhibits would be much more attractive could they be made to occupy at least one-third more space. The aisles between the cases are too narrow; the light is thereby

diminished, and the general view obstructed. The collections in invertebrate paleontology occupy only about one-half the space at present desired, and the space devoted to vertebrate remains will prove ridiculously insufficient so soon as the work now under way of restoring some of the larger remains of Triceratops, Stegosaurus etc., is completed.

The workrooms of the department are at present in a rented building, several blocks from the museum, while hundreds of boxes of materials from the various surveys are stored in the sheds, where not readily accessible. Laboratories and offices are too crowded to admit of satisfactory accommodations for more than the present force. The entire space at present devoted to exhibition and study installation amounts to a little short of 25,000 feet. It is estimated that at the present rate of growth 100,000 square feet will be none too much to supply all the needs of the department during the next ten years.

G. P. M.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Die Ursachen der Oberflächengestaltung des Norddeutschen Flachlandes. von DR. FELIX WAHNSCHAFFE. 9 plates and 33 text-illustrations. pp. 258. Second edition, fully revised. Stuttgart. J. Engelhorn. 1901. 10 marks.

Since the inititial examination and publication by Salisbury and Wahnschaffe on the moraines bordering the southern Baltic in Germany, the glacial geology of Germany has received much more attention than ever before, and especially by Dr. Wahnschaffe. In this volume (which would be much improved by the addition of an index) the author has gathered all the essential facts known relating to this interesting region, whether observed by himself or by others, making a monograph similar to those of Upham and of Leverett on certain portions of the drift of the United States, but less bulky. He describes, and frequently illustrates by diagrams, the various elements of the drift-plains, including their terminal moraines, and concludes with a chapter on post-glacial modifications of the drift, whether by wind or by wave. In giving the order of succession of the north German Quaternary formations, as indicated by the facts presented in the volume, the author presents the following scheme:

POST-GLACIAL.

(a) *Later:* Beech and alder (with Mya).
(b) *Earlier:* Oak (Litorina); Birch, Pine (Ancylus).

GLACIAL.

Latest glacial phase; Dryas (Yoldia); Fauna and flora still subarctic.

Third ice age; (a) Melting period; terminal moraines, sands of valleys and terraces, osars, kames, gravel, loess. (b.) Covering of land ice; Upper marl sand (ground moraines), subglacial sand and gravel.

Second interglacial epoch: Fauna of large animals; interglacial peats; deposits containing fresh-water shells; marine formations containing certain oyster beds, clays, with Cypris and diatoms.

Second ice age: Lower marl sand (ground moraines), fluvio-glacial gravelly, sandy and clayey deposits.

First interglacial epoch: Fresh water deposits, peat and calcareous tufa, sands with Valvata. Marine deposits, sands with Cardium, Yoldia and Cypris. Diatoms.

First ice age: Ground moraines and older fluvio-glacial sediments.

Pre-glacial time: Deposits not yet demonstrated, although some of the fossiliferous beds above assigned to the first interglacial epoch have been considered pre-glacial. N. H. W.

Le granite des Pyrénées, et ses phénomènes de contact. 3 plates, 16 text figures. pp. 68. By A. LACROIX. Ch. Beranger, Paris, 1900. (*Bull. Ser. Carte Geol. France* No. 71.)

The facts and conclusions therefrom given in this bulletin are very important, considered from a petrological point of view. This publication marks perhaps an important epoch in European geological literature. While some of the conclusions have been, here and there, anticipated by earlier publications, in no case have they been so fairly presented, nor so fully supported by reference to field evidence. The author is one of the most skilled and, at the same time, one of the most cautious of living petrographers and he has spent several years in gathering and in studying the field facts, and in the necessary laboratory work. His results necessarily carry conviction to all who are open to conviction. It will be difficult to question them with good reason adversely until the same facts shall have received equally as long and detailed a study. These important results can be summarily stated as follows:

1. The granite of the massif of Querigut-Millas surrounds and incloses along the south side a large band of paleozoic limestone. On the southern border this limestone band is separated from some schists by the enclosing spur of granite.

2. Along the southern side of the granitic massif exomorphism is notable, in the schists and in the limestone, the former taking the character of leptynolytes, or feldspathic mica schists, with frequent development of tourmaline, andalusite, cordierite etc., also sillimanite and microcline. A special type contains abundant orthoclase and oligo-

clase, with biotite and graphite, and still another ilmenite, allanite and epidote. The limestone is mar-morized and garnetized with reddish yellow grossulaire in large rhombododecahedrons. In other places it is rich with epidote and hairy idocrase, with wollastonite, diopside, chabazite and stilbite. In these modifications sometimes microcline and sometimes quartz is in the last mineral formed. Epidote increases to form epidolyte. It is then granulitic and pyroxenic. Sometimes it is rich in sphene, diopside and blue tourmaline. The limestones also take the form of compact dense feldspathic rocks derived from thin alternating beds of limestone and of schist, constituting a banded hornstone. Talc appears also as a product of such modifications, and beds of magnetite as a pneumatolitic product at the contact planes. In the marble are also veins of aplyte and pegmatyte. These veins are not derived from injection from the granitic magma, but from slow molecular filling of fissures by the action of mineralizing waters.

3. Along the northern slopes of the granitic massif the exomorphism is less, and the granite is much decayed and granulated. It contacts on Silurian schists and Premo-Carboniferous and Devonian limestones and on Secondary limestones. The modified sedimentaries present essentially the same characters as on the south side.

4. The granite passes progressively to hornblende granite, then to quartz dioryte, to basic dioryte and to hornblendytes, including noryte and hornblendic peridotyte.

5. These several rocks are separated, in different stages of alterations, from the normal granite, by a form of granite containing inclusions showing different degrees of exomorphism.

6. There is a clear, close connection between the nature of the sedimentaries adjacent and these inclusions, indicating their source.

7. It is logical, therefore, to consider these inclusions sometimes as fragments from the sedimentaries highly exomorphosed or sometimes as portions of the granitic magma endomorphosed by the digestion of such fragments. Yet they approach so closely together in mineral nature that sometimes their source whether in the magma or in the sedimentaries cannot be distinguished.

8. The granitic magma could have absorbed a great quantity of the schists without having its mean composition much altered.

9. The absorption of calcareous sediments produces intermediate phases of basicity in the granitic magma.

These conclusions bear directly on the theoretical origin of the basic and intermediate eruptive rocks, and seem to render the notion of magmatic differentiation unnecessary, and at this place inapplicable. At the same time it should be noted that Prof. Lacroix does not permit himself to *universalize* these results, but states that every case must be studied by itself. N. H. W.

Geologischer Fuhrer durch Campanien. Von DR. W. DEECKE.

This is No. 8 of the collection of geological guides published by Gebrüder Borntraeger, Berlin, 1901. Costs 4 marks. This guide would be particularly valuable to tourists interested in volcanic phe-

nomena. It has, besides general maps, special maps of volcanoes and photographic views of some of their scenery; also a bibliography of the chief literature. N. H. W.

The Coal and Metal Miner's Pocketbook of Principles, Rules, Formulas and Tables. THE COLLIERY ENGINEER COMPANY, Scranton, Pa. Sixth edition, revised and enlarged with original matter. 1900.

This handy and gilt-edged little volume is fully described by its title. It is printed on fine, calendered paper in solid nonpareil type, and contains in small space a vast amount of technical information. It contains a glossary in which are definitions of many Mexican and Cornish terms. This glossary, however, is almost destitute of geological and mineralogical terms. It is apparent that no geologist had part in its compilation. "Archean" is defined as "an early period of geological time." Any geologist would have said *the earliest period of geological time.* The presence, moreover, of such a definition as this: "*Argol*—A crude tartar deposited from wine," is almost a demonstration that some expert other than the geologist selected the terms of this glossary, for no geologist would assume that such crude tartar has any relation to coal or metal mining. N. H. W.

Report on the Geology of the Philippine Islands. GEORGE F. BECKER. (From the 21st Annual Report of the United States Geological Survey. Washington, 1901.)

Mr. Becker has admirably begun the Government's geological work in the Philippines. He has catalogued all earlier geological publications, of whatever nationality, and his deduced from them a compact sketch of what is known of the geological structure and history of the entire group of islands. At the same time he has added his own observations, and has given to the whole interesting sketch a decidedly original and American clearness, as well as completeness.

In the eastern part of Luzon, and of other islands, are crystalline schists and massive rocks, gneiss, granite in small quantity, possibly some syenyte, while diorytes, diabases and gabbros are abundant. Similar formations are found in the eastern portion of other islands. Some of these rocks may be Archean, by analogy with the geology of Borneo and of Java, but the diabases and gabbros are thought to be mainly post-Carboniferous.

Of stratified rock, Dr. Becker states that none are known of pre-Tertiary age— although they may exist, and do exist in adjacent island groups to which the Philippines seem to be allied in one geological province. The Eocene is supposed to exist, but it is not well authenticated. Certain black lignites have been reasonably supposed to be of the Eocene, and that would require the Eocene through the southern provinces of Luzon, and in the Visayas. The Miocene seems to have a basal conglomerate, indicating non-conformity on the Eocene. Other strata are considered Pliocene and post-Pliocene. The islands have received a recent uplift, after peneplanation, thus forming extensive plains that are fertile, and thickly settled. This uplift began in the

later Miocene and still continues, being marked by successive terraces and by elevated coral limestones.

The author thus summarizes the probable geological history of the Philippines:

"Summarizing the foregoing facts and inferences, it would seem that the geological history of the Philippines is something as follows: From early Paleozoic times onward an archipelago has usually marked the positions of these islands. Prior to the Eocene nothing definite is known of them, but further investigation will very likely disclose Paleozoic and Mesozoic strata there as in the Sunda and the Banda islands. During the Eocene it is probable that the lignitic series of Cebú was deposited, and the contorted indurated strata, which in other localities also carry black lignite relatively free from water, should be referred provisionally to this period. Whether the nummulitic limestone found at Binangonan is Eocene seems to me to be an unsolved question. After the Cebúan lignitic epoch a great uplift and folding took place, and this may have been a detail of the late Eocene movement which so profoundly modified Asia and Europe. It must have brought about temporary continuity of land area between Borneo and Luzon. Somewhere about the middle of the Miocene the country sank to a low level. Many of the present islands must then have been far below water, while Luzon and Mindanao were represented by groups of islets. Observations appear to suggest that the Agno beds represent the basal conglomerate formed at this subsidence. A slow rise began again during the later Miocene, and may have continued to the present day without inversion, yet the actual distribution of living forms is such as to give some grounds for believing that, at some intermediate period, the islands were a little higher than they now are, but sank again only to rise afresh. The diorytes and associated massive rocks, including their tuffs, may have made their appearance about the close of the Paleozoic. The less siliceous of these rocks seem to have followed the more siliceous intrusions as a whole. The gold deposits, and perhaps other ores, are so associated with these massive rocks as to indicate a genetic relation. The neo-volcanic period began as early as the highest Miocene horizon, and very probably at the post-Eocene upheaval. If the semi-plastic marls of Cebú are all Miocene, the earlier andesitic rocks, at least, date back nearly to the great up-heaval. Among these rocks, also, there is sometimes a tendency for the basalts to follow the andesites, but the one dacite found at Corregidor is later than the andesites of that island. The relation of the trachytes to the andesites is not certain, but the sanidine rock is probably the earlier. A very large part of the neo-volcanic ejecta has fallen into water and been re-arranged as tuffaceous plains. The volcanic vents appear to me to occur rather on a net work of fissures than on a single system of parallel diaclases, and the volcanic activity is to be regarded as a thermal manifestation of the energy of upheaval." N. H. W.

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Two new genera and some new species of fossils from the upper Paleozoic of Missouri. (Am. Geol., vol. 27 pp. 343-355, pl. 28. June, 1901.)

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Sketch of the life and work of Augustus Wing. (Am. Geol., vol. 28, pp. 1-8. Portrait. July, 1901.)

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Willmott, A. B.

Michipicoten Huronian area. (Am. Geol., vol., 28, pp., 14-19, pl. 8. July, 1901.)

CORRESPONDENCE.

Recent Submergence of the Asiatic Continent. As I have not yet had time to present in detail the facts which led me to become convinced of the recent extensive subsidence of the Asiatic continent, I may be permitted in advance to mention two points which will help to clear up the doubts expressed by Prof. Claypole in his communication to the July number of the American Geologist.

The first point relates to the origin of the loess in northern China. Prof. Geikie, on page 699 of the revised and enlarged edition of his "Great Ice Age," in 1895, gives expression to the same opinion that is entertained by Prof. Claypole, that the material of the loess is "largely of fluvio-glacial origin,' while on a previous page (697) he accepts without reservation, the statement of Przevalski that "undoubted traces of former glaciation are seen in the Suma-Hada range, west of Kalgan in China." In his map facing page 691 Geikie also represents this region west of Kalgan as containing an extensive glaciated area.

Believing at the outset, as I did, in the glacial origin of loess material and in the probable correctness of Przevalski's inference, I took a 450-mile ride on muleback into the Mongolian frontier to verify the theory. This enabled me both to see the most significant deposits of loess in China and to cross and recross the mountains on the border of the Mongolian plateau where the glaciers must be located to furnish the loess material for that region, if indeed it were of glacial origin. But though traversing this most probable glaciated area for a distance of 150 miles, we found not only no evidence of any former glacial occupation, but abundant evidence that there had been no glaciation of the region. The whole erosion of the region has been sub-aerial, rather than subglacial.

If our conclusions be correct (and they accord with those of Richthofen) the glacial origin of the loess of northeastern China must be abandoned; and if abandoned there, I see not why it should, except on special evidence, be maintained with reference to other localities. Furthermore, though our examination of the facts along the base of the Ala-Tau mountains in Turkestan was not so complete as that in eastern Mongolia, it was such as to leave little doubt in our minds that the glacial phenomena of those mountains were entirely incompetent to account for either the amount or the distribution of the loess over which we traveled for many hundred miles.

A second point which was made in my paper published in the *Quarterly Journal* of the London Geological Society (vol. lvii, 1901, p. 249) relates to the extensive deposit of beach gravel upon the face of the precipitous cliff of volcanic rock which rises immediately behind Trebizond on the Black sea. This deposit reaches to a hight of 750 feet above the sea, and is of a character and extent such as utterly precludes its accumulation in any other way than by wave action at that level. The material is not local, it is much rounded, it is out of all possible relations to any local streams which might have deposited it, it is fresh in appearance, and is subsequent to all the principal rock erosion of the region. In presence of these facts, our failure to find seashells, or indeed the total absence of seashells, would not weigh strongly in the balance against the inference that they indicate a recent water level of the Black sea.

Since returning home one of my pupils, who is skilled in such investigations, informs me that he has found a similar deposit near Samsoun, which is also upon the Black sea about one hundred miles to the west. But I will not anticipate the full statement of the facts which I hope to make when the present pressure of my daily duties shall be removed. G. FREDERICK WRIGHT.

Oberlin, July 22, 1901.

BILLINGS AND HIS BIBLIOGRAPHY: Will you please add the following titles to the bibliography of Elkanah Billings, given in the May number of the AMERICAN GEOLOGIST? I am indebted to major A. W. Vogdes of Brooklyn, for four of these references.

1860.

Additional Note on the Potsdam Fossils Amer. Jour. Sci & Arts, Vol. 30, 1860, 2d Ser., pp. 337-338; New Haven, Conn.

1862.

On professor Hall's Claim of Priority in Determination of the Age of the Red Sandstone of Vermont. Amer. Jour. Sci. & Arts, 2d Ser., Vol. 33, pp. 370-376, 1862; New Haven, Conn.

1865.

Notice of Some New Genera and Species of Palaeozoic Fossils. Can. Nat. & Geol., Vol. 2, 2d Ser., pp. 425-432, Dec., 1865; Montreal, Canada.

1869.

Note on the Structure of the Blaistodea. Amer. Jour. Sci. & Arts, Vol. 47, p. 353, 1869; New Haven, Conn.

1872.

On Some New Species of Paleozoic Fossils. Amer. Jour. Sci. & Arts, Vol. 3, 3d Ser., pp. 352-360; New Haven, Conn.

Ottawa, Can. H. M. AMI.

PERSONAL AND SCIENTIFIC NEWS.

PROFESSOR W. M. DAVIS is in the west, on a second geological trip to the Grand Cañon.

PROF. H. F. OSBORN spent part of June inspecting the work of his exploring parties in Wyoming.

MR. S. F. EMMONS will make a supplementary report on the Leadville mining district of Colorado.

DR. C. P. BERKEY, of Minneapolis, made a professional visit, in July, to mining points in Montana.

DR. W. D. MATTHEW, of the Am. Mus. Nat. Hist., is in eastern Colorado hunting for fossil vertebrates.

AT JOHNS HOPKINS UNIVERSITY Dr. H. F. Reid has been promoted to the professorship of geological physics.

DR. U. S. GRANT, of Evanston, was enegaged recently in the investigation of certain graphite deposits in Georgia.

DR. JOS. LE CONTE, professor of geology and natural history at the University of California, died June 6, aged 88 years.

MR. GEO. H. ELDREDGE will examine and report on the oil regions of California for the United States Geological Survey.

MR. J. B. WOODWORTH is continuing, for the New York survey, his study of the problems of submergence in the state.

THE ONTARIO BUREAU OF MINES has a fine exhibit of the minerals and ores of the Province at the Pan-American Exposition.

DR. E. O. HOVEY, of the Am. Mus. Nat. Hist., is spending several weeks in the Black Hills region collecting Jurassic invertebrates.

A PROFESSORSHIP OF GEOLOGY has been established at the University of Colorado, the first appointment being Doctor N. M. Fenniman.

MR. J. S. DILLER, of the United States Geological Survey, will examine the geology of the mining district at Bully Hill, Shasta county, California.

PROFESSOR W. G. TIGHT, of Denison University, has resigned, to become president and professor of geology in the University of New Mexico.

THE HONORABLE C. D. WALCOTT was recently given an honorary LL. D. at Chicago University, and Mr. Arnold Hague a D. Sc., at Columbia University.

MR. G. D. HUBBARD, recently a graduate student at Harvard University, has been appointed instructor in geography at the State Normal School, Charleston, Illinois.

DR. GILBERT VAN INGEN has severed his connection with Columbia University and, during the present season, is engaged

in field work on the lower paleozoic formations about the Adirondack mountains for the New York geological survey.

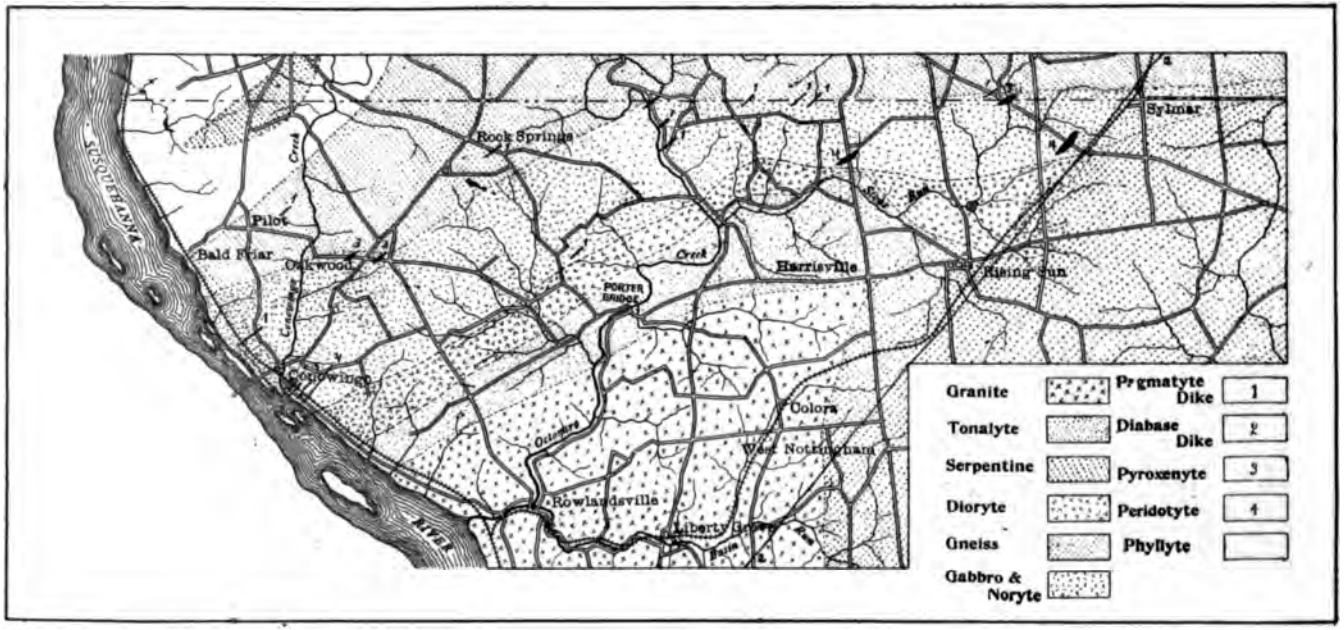
IN WESTERN WYOMING oil was accidentally discovered by the operators in the construction of a railroad. It naturally flowed about five barrels per day. Immediately numerous companies were incorporated, and large tracts of land were taken up for oil prospectors.

THE DEATH OF DR. THEO G. WHITE, an active and able young geologist, of New York, July 7, is the cause of deep and sincere regret. There is a peculiar sorrow connected with the decease of such a young man, well equipped for his profession, who had a resasonable expectation and promise of many years of honorable service. We may present in the future a more suitable sketch of his life.

THE MISSOURI GEOLOGICAL SURVEY.—Governor A. M. Dockery on May 23d appointed a new board of managers of the Bureau of Geology and Mines. On June 14th, the following gentlemen were elected as officers of the board: Prof. E. M. Shepard, Springfield, Mo., vice-president; Dr. E. B. Craighead, secretary; Col. H. H. Gregg, Joplin, Mo., and Dr. W. S. Allee, Olean, Mo. The Legislature ordered the removal of the survey headquarters to the School of Mines at Rolla. The state geologist will soon be appointed.

DOCTOR R. A. DALY has resigned his position as instructor in physiography at Harvard University, to accept a position on the Geological Survey of Canada. The work to which he has been assigned is the survey of a belt of country immediately adjoining the international boundary, on the Canadian side, and extending across the continent. The start was made about July 7th, near the foot of Mt. Baker, and Dr. Daly will keep pace with the party which is making a re-survey of the boundary. On account of this call, the expedition planned for Greenland and Baffin Land had to be abandoned, although arrangements down to the last detail had been made for it.

MOUNT MCKINLEY. Mr. Robert Muldrow, in the *National Geographic Magazine* for August, gives an account of the highest mountain in North America, 20,464 feet. It is in Alaska, situated at the headwaters of the Sushitna and Kuskokwim rivers. The range is a portion of the Cordilleran system of North America. The mountain group is extremely rugged, and is covered with snow and ice to within 2,000 or 2,500 feet of the sea level, giving source to numerous glaciers. This mountain was first named and described in print by Mr. W. A. Dickey. Mr. Muldrow in 1898 made triangulation measurements from six different points. The average, for altitude, is as given above, and the latitude is 63° 5′ north, the longitude being 151° west.



GEOLOGICAL MAP OF THE ERUPTIVE ROCKS OF NORTHWESTERN CECIL COUNTY, MARYLAND.

THE

AMERICAN GEOLOGIST.

Vol. XXVIII. SEPTEMBER, 1901. No. 3.

THE BASIC ROCKS OF NORTHEASTERN MARYLAND, AND THEIR RELATION TO THE GRANITE.

Arthur Gray Leonard, Des Moines, Iowa.

PLATES XV-XIX.

INTRODUCTION.*

This paper contains the results of the study of a limited area of igneous rocks in which are found a number of different types ranging all the way from acid to ultra-basic. It is intended to show that these types are intimately associated in their geological occurrence and closely related in composition; that many of the types graduate into others by intermediate varieties, and that they probably represent facies of one original magma.

The study of these eruptive rocks was suggested by the late professor G. H. Williams, and the field work was commenced and carried on during the greater part of the month of June, 1893. At the same time the investigation of the granites lying just to the south was taken up by G. P. Grimsley and the results of his studies have already been published.† Accompanying his paper is a map, on which are represented not only the granites, but also the basic rocks lying to the north. The data concerning the distribution of the latter were furnished by the present writer and represent the views

*The writer is under special obligation to Dr. H. F. Reid, of the Johns Hopkins University, for the photomicrographs in this paper, which were made in the geological laboratory of the University. He is also much indebted to professor W. B. Clark and Dr. E. B. Mathews, of the same University, for helpful suggestions and for assistance rendered in many ways.

†The granites of Cecil county in northeastern Maryland. Jour. Cincinnati Soc. Nat. Hist., Vol. 17, pp. 59-67; 78-114. Cincinnati, 1894.

held after the preliminary survey of the field. Subsequent work has led to some changes in the boundaries of the gabbro and serpentine and has brought to light additional rock types which are not represented on the previous map.

It was later found necessary to discontinue the study of the area and not until the autumn of 1897 was the work resumed. The region was then revisited under the auspices of the Maryland Geological Survey and the investigations were extended beyond the area previously studied.

GENERAL DESCRIPTION OF THE AREA AND ITS ROCK TYPES.

Location and Extent. The area of basic rocks treated in this paper lies within the belt of ancient crystallines which extends along the eastern flank of the Appalachian mountains, forming what is known as the Piedmont plateau. The formations which compose the Piedmont region are generally considered as pre-Cambrian and are therefore Archean and Algonkian in age. They are separated from the coast by the unconsolidated deposits of the Coastal plain. In Maryland the crystalline region is divisible into two portions; the western half consists of unfossiliferous and only slightly metamorphosed rocks which are of undoubted sedimentary origin; in the eastern division the rocks are wholly crystalline and show little or no certain evidence of clastic origin except in such infolded masses as the Deer Creek quartzytes and Peach Bottom slates. In this eastern portion of the Piedmont belt the rocks are chiefly gneisses, schists and marble, through which have broken eruptive masses of granite dioryte, gabbro, pyroxenyte and peridotyte. It is with one of these areas of eruptive rocks that this paper deals.

The rocks under discussion form a long, narrow belt extending in a general southwesterly direction from a point in Cecil county eleven miles west of the Delaware line, through Harford and into Baltimore county, to a point fifteen miles northeast of Baltimore. It has a length of about thirty-five miles and a width varying from two to three miles. The Susquehanna has cut its channel across this mass of igneous rocks, dividing it into two parts. This paper treats especially of that portion lying to the east of the river, in Cecil county, embracing an area of approximately twenty-two square miles. The types

herein described are representative of those occurring throughout the entire belt and possess a special interest on account of the close association of the basic eruptives with the granites which border them on the south.

In addition to the larger mass there are three smaller ones. The "Stony Forest" area is the most extensive of these and is situated in Harford county, between five and six miles east of Bel Air. It has a length north and south of five miles and width of about three miles. Of the other two, which are not as large, one lies just north of Calvert (Brick Meeting House), extending a short distance into Pennsylvania, and the other about one-half mile northeast of Elkton, near the eastern border of the state. The latter, as shown by Chester, is a western prolongation of a larger area in Delaware.

AREAL DISTRIBUTION AND GENERAL DESCRIPTION OF ROCK TYPES.

The rocks embrace many different types distributed in a series of zones trending northeast-southwest. They include quartz-mica-hornblende-dioryte, quartz-dioryte, noryte, gabbro, pyroxenyte, peridotyte, serpentine and diabase. Occurring along the southern margin of the area next the granites are the quartz-mica-hornblende-diorytes, or tonalytes. Passing northward these are in general succeeded by coarse-grained hornblende-diorytes, which commonly carry considerable quartz in good sized grains. These hornblendic rocks are in turn followed by norytes and gabbros, which are bordered on the north by the serpentine mass. The latter lies along the edge of the area and extends across the line into Pennsylvania. Coarse pyroxenytes are found along the boundary between the noryte and serpentine and both non-feldspathic types occur in dykes within the gabbro and noryte. (See map, plate xv.)

It is not possible to draw any sharp line of separation between the granite and tonalyte, for these are connected by intermediate types and thus graduate the one into the other. The tonalyte varies considerably in appearance according to the fineness or coarseness of the grain and the relative proportion of the light and dark constituents. As a rule it is a medium coarse-grained, granular rock of a grayish color. Dark patches or segregations of finer grained material rich in biotyte fre-

quently occur in these tonalytes as well as in the granites. The former is composed of lime-soda feldspar, quartz, hornblende, biotite and a little orthoclase. Magnetite, apatite, zircon, sphene (titanite) and garnets are present as accessory constituents, and more or less secondary epidote is almost always found.

The hornblende-dioryte is a common type throughout the area. It is a coarse-grained aggregate in which striated feldspar and black, compact hornblende can be readily distinguished with the unaided eye. More or less quartz is usually present and not uncommonly a little accessory biotite. On a fresh surface the rock has a mottled appearance due to the white feldspar standing out against the dark hornblende. But when it has been much weathered the surface becomes much pitted on account of the removal of the plagioclase. When quartz forms one of the constituents the other minerals weather out and leave the former projecting, giving the rock a rough exterior which is highly characteristic of the quartz-dioryte. The abundance of blue quartz is a noticeable feature of this type. It is commonly in good sized grains ranging from one-eighth to one-sixteenth of an inch (one and a half to three millimeters) in diameter. With an increase in the amount of biotite this rock passes over into tonalyte.

The most abundant rock type in the whole area is probably the noryte, with which the gabbro is closely associated. The constituents of the former rock that are readily distinguishable are a greenish black or reddish brown hypersthene, often with a bronzy, metallic luster, and fresh striated feldspar. In addition a little secondary diallage is usually present. The noryte is a medium coarse-grained, granular rock, often with a crumbly appearance due to its loose texture. It varies in color from gray to almost black, but the light colored varieties are the more prevalent. A noticeable peculiarity of this type is the development of green hornblende along certain planes where there has probably been more or less stress. These green bands, which have a width of several millimeters, usually stand out conspicuously on a weathered surface. In this region the norytes are more abundant and important than the gabbros. They differ from most of the other types of the area in being as a rule remarkably fresh and unaltered. One specimen each

of quartz noryte and olivine noryte was collected but these varieties are rarely found. Still more interesting is the occurrence of a saussurite noryte in which the feldspar is completely altered to zoisite and the hypersthene partially changed to fibrous hornblende. A porphyritic variety with large phenocrysts of diallage occurs at the Mount Hope church. With an increase in the amount of diallage the noryte passes over into hypersthene-gabbro. While this rock is in general more compact and somewhat darker in color than those just described, it often bears a close resemblance to them. The diallage is seldom more abundant than the orthorhombic pyroxene and the latter is always present in large amount.

If compared with the diorytes occurring along the southern border of the area, the hypersthene-gabbros, as well as the norytes, are seen to be noticeably finer in grain. Where the gabbro outcrops at some points, notably along Octoraro creek and on the Susquehanna, it is seen to have been considerably altered and bears slight resemblance to the original rock. The plagioclase is no longer bright and transparent, but is changed to a dull, opaque saussurite, while the pyroxene has also altered into a greenish, fibrous hornblende. The resulting rock, which is a typical saussurite gabbro, has a light greenish color and a mottled appearance due to the white and green minerals composing it. Olivine gabbro is of rare occurrence in this region, only a few specimens being found.

By the alteration of the pyroxene to secondary hornblende the hypersthene-gabbro has in some cases been changed into gabbro-dioryte or metagabbro. But this metamorphic process does not appear to have gone on very extensively and these secondary diorytes are comparatively rare.

Numerous diabase boulders were observed just east of Rising Sun, and at various points near the railroad between that locality and the state line. These are doubtless derived from the trap dike traced by H. C. Lewis through southeastern Pennsylvania to the Maryland boundary, which it crossed not far from Sylmar station.* The rock is very fine-grained and compact.

Pyroxenytes and peridotytes occur in dikes and lens-shaped masses in the noryte and gabbro. The former is also abundant

*American Philosophical Society, May 15, 1885, 19 pp.

along the serpentine border, where it appears to be a basic facies of the noryte, into which it merges by intermediate varieties. This non-feldspathic type is a coarse-grained aggregate in which the constituents can readily be distinguished; they are a reddish brown hypersthene with which is associated a greater or less amount of greenish diallage. These pure pyroxene rocks are found in the vicinity of Oakwood, along the state line north of Rising Sun and at several other localities.

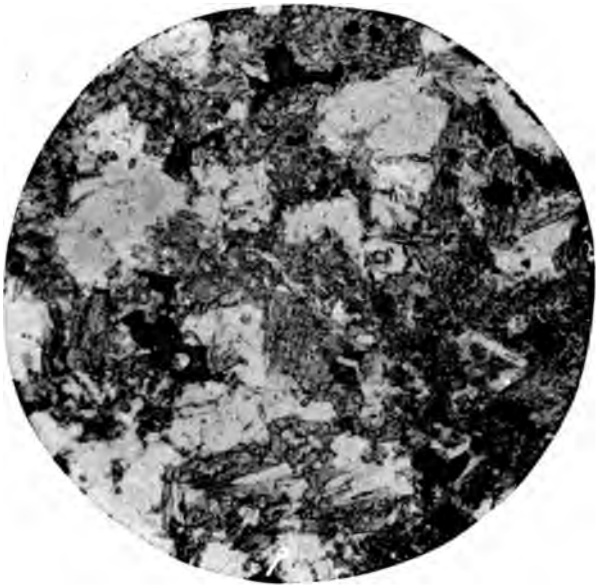
The peridotytes are likewise coarse-grained and frequently have a porphyritic structure. They contain olivine in addition to the pyroxenes. The largest mass is near the Mount Hope church, one mile and a half northeast of Rising Sun, where the rock has the peculiar mottled appearance known as poikilitic, due to the dissemination of small grains of greenish olivine through large individuals of pyroxene. When the light is reflected from a cleavage surface these grains form dull spots. Other localities for these olivine rocks are at the Oak Grove schoolhouse, two miles northwest of Rising Sun; along Octoraro creek above the paper mill, and beside the railroad just south of Conowingo.

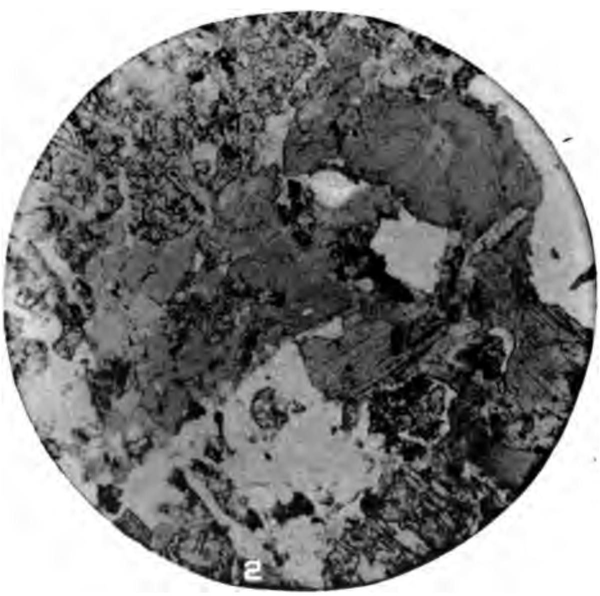
The serpentine borders the noryte-gabbro mass on the north. It is known as the "State Line serpentine" on account of its occurrence along the boundary between Maryland and Pennsylvania. The greater portion of the mass lies across the line in Chester county. The southern margin coincides approximately with the line as far west as Octoraro creek, where it bends to the south and enters Cecil county. The area has a length east of the Susquehanna river of seventeen miles and an average width of one mile. Between Conowingo creek and the river there is another small mass of serpentine which extends across from Lancaster county, Pennsylvania. The region over which this rock outcrops presents an uninviting and desolate apeparance, making very appropriate the term "barrens," which is often applied to it.

PETROGRAPHICAL DESCRIPTION OF ROCK TYPES.

DIORYTE.

The diorytes are confined to the southern edge of the area where they form a belt varying from one to one and a half miles in width, the widest portion being near the eastern end.

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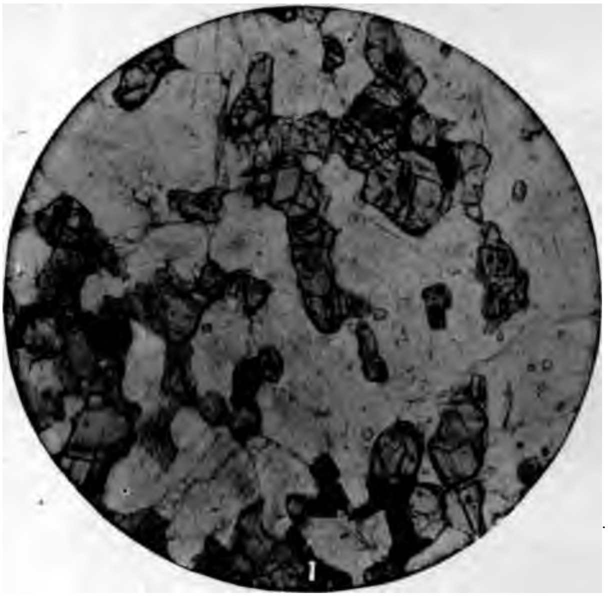

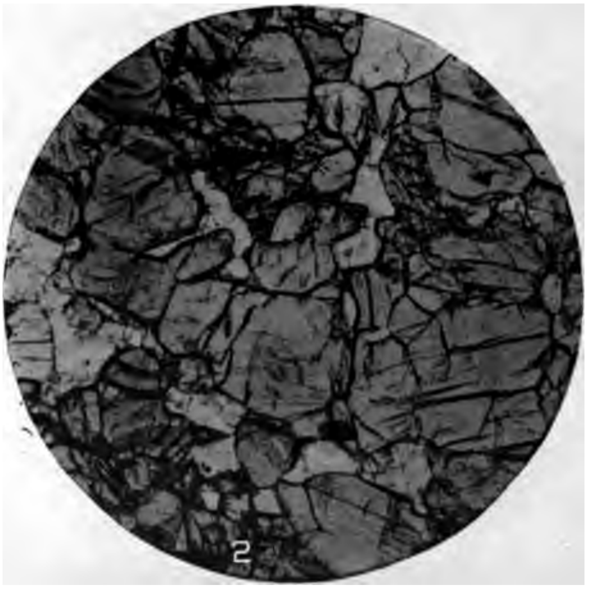


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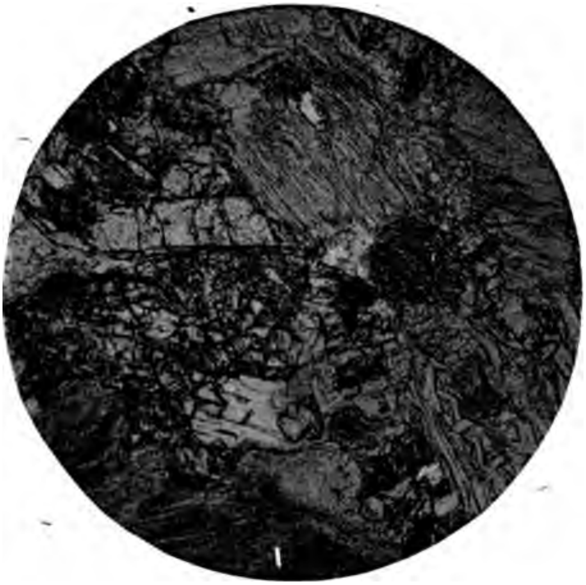

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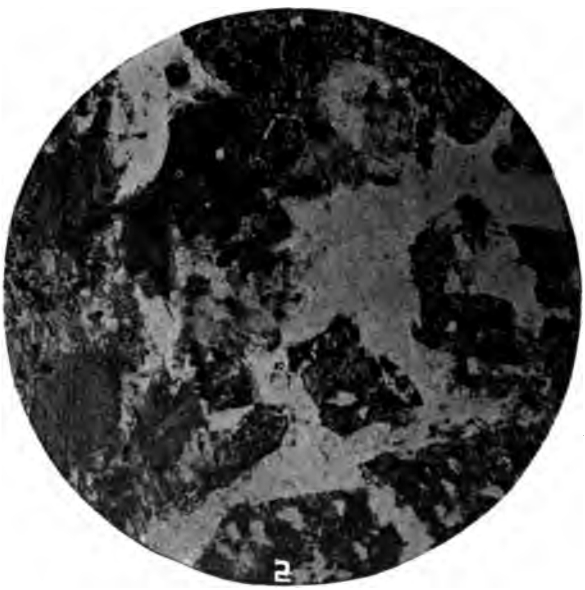

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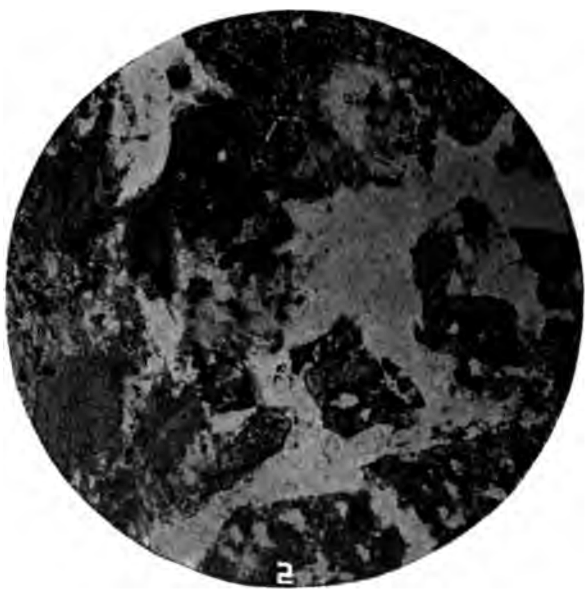
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They are found best developed in Cecil county, where they lie between the granites on the south and the gabbros and norytes on the north. While the diorytes are found west of the Susquehanna river in Harford county, they do not there form so well defined a zone bordering the main eruptive mass.

It is not possible to draw any sharp line of separation between the granite and dioryte. On the south this rock passes by intermediate types into the biotite-granite of the Rowlandsville area, which, as will be shown later, has very much the composition of a dioryte. Along the northern border the diorytes are intimately associated with the gabbros and norytes, but the transition from one to the other is not well marked, as in the case of the granites, and intermediate types between the pyroxene and hornblende rocks are rare.

Two varieties of dioryte are present in the area, namely, a quartz-dioryte and a quartz-mica-hornblende-dioryte. The former is confined for the most part to the northern portion of the dioryte belt, next to the norytes; the latter is found mostly in the southern portion where it passes into the biotite-granite. For the purpose of description it will be convenient to consider these separately, taking up first the most acid variety.

Quartz-mica-hornblende-dioryte. This rock is found at many points between Rising Sun and the Susquehanna; it is abundant along Stone run, extending south of that stream as far as the Harrisville road; large boulders of it are numerous at the foundry, and at Harrisville, and outcrops occur at the junction of Stone run and Octoraro creek, at Porter Bridge, and along the road leading westward from the bridge to the Rowlandsville road. Across the Susquehanna river in Harford county good localities for this rock are near Darlington, and one mile east of Thomas Run P. O., on the south side of Deer creek.

This dioryte varies considerably in appearance according to the fineness or coarseness of the grain and the relative proportions of the light and dark constituents. As a rule it is a medium coarse-grained, granular rock of a grayish color, such as that occurring south of Stone run. It is very granitic in appearance and might easily be mistaken at first sight for a hornblende-granite. The dioryte of the Porter Bridge region is darker in color, often fine-grained, and the hornblende usually

occurs in good sized allotriomorphic individuals which occasionally reach a length of over one-quarter of an inch (six millimeters). This tendency toward the development of a porphyritic structure is quite marked in some cases.

Dark patches or segregations of finer grained material rich in biotite frequently occur in these rocks. No evidence was found for considering them as inclusions rather than segregations. As already stated, the dioryte varies considerably in grain within short distances and these dark patches appear to be merely accumulations of such fine grained material. These segregations, which are also found in the Rowlandsville granite, do not increase in size or number as the diorite mass is approached. They will be considered more at length in another place.

The mineral constituents of this dioryte which can readily be distinguished are hornblende, biotite, plagioclase, quartz, and a little orthoclase. Some accessory magnetite and apatite is usually present, together with a little zircon and sphene (titanite). Garnets are not uncommon and epidote and chlorite occur as secondary minerals. Mineralogically these diorytes containing biotite and quartz maybe classed as tonalytes, though they contain a relatively larger proportion of the ferro-magnesian constituents than the typical tonalyte from Adamello, described by vom Rath,* and are poorer in silica. Through a decrease in the hornblende and a corresponding increase in the biotite they pass into the biotite-granite or mica-dioryte and by a loss of biotite and corresponding increase of hornblende they graduate into the quartz-dioryte. Such transition types are of common occurrence.

The *feldspar* of these quartz-mica-hornblende-diorytes is mostly acid labradorite, though some orthoclase is also present. Stauroscopic measurements on cleavage pieces gave —5° to —6° on oP (001) and —15° to —17° on $\infty P \breve{\infty}$ (010). With the loss of the hornblende and increase in the amount of feldspar and quartz the plagioclase grows more acid and in the biotite-granite (mica-dioryte) it was found to be oligoclase. The feldspar is usually finely striated, due to repeated twinning according to albite law. Occasionally one set of striations is crossed by another nearly at right angles, indicating the pres-

*Zeit. der deutschen geol. Gesellsch., XVI, 1864, p. 249.

ence of twinning according to both the albite and pericline laws. Zonal structure is frequently found but is more or less obscured by the alteration which has taken place in the feldspar. The plagioclase is quite free from inclusions and differs in this respect from that of the gabbros and norytes.

The alteration of the feldspar to epidote has gone on very extensively. All stages of this progress of epidotization were observed from that in which the change has only just commenced to that in which the epidote has almost replaced the original mineral. At first the plagioclase contains only small scattered crystals and the twinning lamellæ are still evident. As the alteration progresses the epidote crystals become more numerous and crowded together; larger individuals also appear, often with no regular crystal outline. The feldspars in the sections now appear opaque on account of the accumulation of minute, closely compacted crystals which fill them and prevent the light from passing through. The hand specimens show that the feldspars have lost their glassy appearance and become dull and white. The crystals of epidote have no definite arrangement, but are distributed in an irregular manner through the host. In most instances the outer edge of the crystal is free from epidote, the latter being confined to the inner portions of the feldspar individuals.

The *hornblende*, which is compact and green, is, next to the feldspar, the most abundant constituent. It seldom occurs in well defined crystals, but is usually in imperfectly developed individuals or confused aggregates. Occasionally, as in some of the diorytes near Porter Bridge, the prismatic faces are well developed and give rise to columnar forms which on weathering stand out upon the surface. Twins are not uncommon, the twinning plane being the orthopinacoid. One basal section of such a twin showed several twinning lamellæ intercallated between the two larger halves.

The pleochroism is very pronounced and does not differ from that usually found in hornblende.

Quartz is an abundant constituent of most of the diorytes.* It is commonly in good sized grains readily distinguishable in the hand specimens and usually of a beautiful blue color. The larger individuals not infrequently show shattered borders due to mechanical deformation, and this granulation may effect the

entire grain, which is broken into pieces. These unite to form a mosaic of interlocking fragments which still preserve the outline of the original grains. The quartz is filled with numerous very minute fluid inclusions. Occasionally it contains in addition many fine needles, probably of rutile, but they are too small for the satisfactory determination of their character.

Biotite occurs in plates or lamellæ without crystal boundaries. It is very strongly pleochroic, the rays parallel to the cleavage ($\mathfrak{b}$ and $\mathfrak{c}$) being dark brown, and those at right angles ($\mathfrak{a}$) light yellow. Inclusions of apatite, epidote and magnetite are common in the biotite.

As accessory constituents magnetite and apatite are almost always present, and titanite occurs occasionally. The epidote is never absent from these diorytes and though it may in some instances be primary it is usually a secondary product developed during the alteration of the feldspar. It commonly occurs in well defined crystals, irregular grains or compact aggregates.

Quartz-dioryte. As already stated the quartz-diorytes occur chiefly along the northern border of the dioryte belt next the norytes and gabbros. As one passes north across the area the dioritic rocks are seen to grow darker in color, and there is a decrease in the amount of biotite accompanied by a corresponding increase in the hornblende. The quartz-dioryte and the tonalyte are thus connected by intermediate types and graduate into each other. By a decrease in the amount of quartz this rock passes into a true hornblende-dioryte.

Among the many localities where the quartz-dioryte occurs the following may be mentioned; north of Rising Sun along Stone run; at McKinsey's mill on the same stream, where it outcrops near the bridge, and along the Susquehanna one mile below Conowingo. In Harford county it is found one half mile south of Bel Air, along Deer creek, one and half miles southwest of Darlington and at numerous other points.

The quartz-diorytes have a medium coarse-grained texture and are dark, almost black, in color. On a fresh surface they have a mottled appearance due to the black hornblende standing out against the white feldspar and quartz. The minerals composing the quartz-dioryte are plagioclase, quartz, hornblende, and occasionally a little accessory biotite. Other ac-

cessory constituents shown under the microscope are magnetite and apatite together with a little titanite (sphene) and zircon. Epidote and chlorite are common secondary minerals.

The feldspar is acid bytownite. Stauroscopic measurements showed extinction angles on oP (001) of —18° to —20° and on the $\infty P \breve{\infty}$ (010) of —30°. The specific gravity as determined by means of the Thoulet solution was in one specimen 2.71, in another 2.72.

Quartz is occasionally present in small amount and cannot be detected without the aid of the microscope. The rock thus passes into a true hornblende-dioryte with a little accessory quartz, and this type is very basic in composition as shown by the accompanying analysis. As a rule, however, the quartz occurs in good sized grains and is blue in color, resembling in all respects that found in the tonalytes. The hornblende does not differ from that already described under the quartz-mica-hornblende-diorytes.

Metamorphic changes. The diorytes have undergone considerable alteration through the extensive epidotization of their feldspar. The various stages in this process can be traced from where there are only scattered crystals of epidote and the plagioclase is still clear and bright to where, as an opaque white mass, it is almost wholly replaced by a compact aggregate of separate epidote individuals. In no instance was complete replacement observed to have taken place, although often only slight traces of the original feldspar remain. This is genetically the same process as the saussuritization of the feldspar that has gone on so extensively in the gabbros and has resulted in the replacement of that mineral by zoisite. In the latter case no iron is required, while in the formation of epidote this element is necessary. It is doubtless derived from the hornblende, or in case of the dioryte containing biotite some of the iron may be supplied from the latter source.

The following very complete analyses of both varieties of the dioryte were made by Mr. W. F. Hillebrand of the United States Geological Survey. I is an analysis of a typical quartz-mica-hornblende-dioryte from near the foundry on Stone run. This rock, which is quite granitic in texture and appearance, is composed of labradorite, quartz, hornblende and biotite, together with a little magnetite, apatite, titanite (sphene) and ortho-

-clase. An analysis of a somewhat more basic variety of the same rock from an outcrop on Octoraro creek at Porter Bridge, is given under II. It differs from the other dioryte chiefly in structure and is typical of the rock occurring in the vicinity of Porter Bridge. III is an analysis of a hornblende-dioryte poor in quartz from three-quarters of a mile northwest of Rising Sun. It is composed of bytownite and hornblende with a little quartz, magnetite, apatite and titanite (sphene). This rock contains less quartz and is therefore somewhat more basic than the true quartz-diorytes of the area. This analysis (III) agrees closely with that of a dioryte from Thuringia which Rosenbusch* gives as an example of a dioryte poor in or free from quartz. The Thuringia rock is likewise composed of bytownite and hornblende.

	I.	II.	III.
SiO_2	58 57	55.16	44 04
TiO_2	1.41	.64	.2.24
ZrO_2	.09	.02	.10
Al_2O_3	16.10	17.51	20.01
V_2O_3	.02 (018)	.04 (036)	.05 (053)
Cr_2O_3	none	trace	none
Fe_2O_3	2.89	2.62	4.22†
FeO	6.12	5.83	8.61†
NiO, CoO	none	.01	.01
Mn	.18	.15	.28
CaO	7.39	8.50	11.68
SrO	trace	trace	none
BaO	trace	trace	none
MgO	2 33	4.35	5.01
K_2O	1.01	1.08	.15
Na_2O	2.11	1.83	1.24
Li_2O	trace	trace	trace
H_2O below 105° C.	.21	.18	.11
H_2O above 105° C.	1.27	2.01	1.90
P_2O_5	.37	.21	.52
FeS_2‡	trace	§.30 (02 S)	.25 (135 S)
CO_2	none	none	none
Cl	undet.	undet.	undet.
Fl	undet.	undet.	undet.
	100.07	100.17	100.42
Sp. gr.	2.890	2.902	3.037

*Elemente der Gesteinslehre. 1898. p. 140.
†Subject to correction for influence of possible pyrrhotite.
‡Sulphur calculated as FeS_2, but exists as pyrrhotite or other sulphides soluble in HCl.
§Perhaps mainly pyrrhotite

NORYTE.

The norytes are closely associated with the hypersthene-gabbros and together they form a long and narrow belt bordering the diorytes on the north. The area occupied by these pyroxene rocks extends from the vicinty of Reckord, on the Little Gunpowder, across Harford and northeast Cecil counties to the Pennsylvanian line. It here changes its course and runs parallel to the boundary, gradually narrowing to the east. While these two types are associated thus closely and merge into each other so that no sharp line can be drawn between them, it will be advantageous to consider each one by itself.

The norytes are not confined to any particular portion of the district, but have a wide distribution throughout the area of basic rocks. Good outcrops are found along the Susquehanna, both above and below the mouth of Conowingo creek, and also on either side of Octoraro creek above the paper mill. Boulders of noryte are common at many points between Stone run and the state line, near Oakwood, along the serpentine border south of Rock Springs, and at numerous other localities. In Harford county they are abundant at Dublin, Castleton, and at Husbands Forge on Deer creek. The rock of which these outcrops and boulders are composed varies widely in color and texture. Some are dark, others are light colored, while many have a purplish tinge. As a rule, they are medium coarse-grained, but not as coarse as the diorytes. They are sometimes firm and compact, but more commonly have a rather loose texture and a more or less crumbly appearance. But as a matter of fact the grains are held firmly together and the rock does not readily break in pieces. Quite a common type is one composed of rounded grains of reddish-brown hypersthene and colorless feldspar, the latter mineral forming but a small part of the mass and serving as a cement for the rest. This variety approaches pyroxenyte in composition and graduates into the latter type by intermediate stages. A porphyritic noryte was found near the Mount Hope church. This contained good sized phenocrysts of diallage, some measuring one-half an inch (13 millimeters) in length, imbedded in a fine-grained groundmass of plagioclase and hypersthene. The diallage contained inclusions of the latter mineral. In another variety which was seen just north of Conowingo the minerals

have a linear arrangement, thus giving the rock a well marked banded appearance.

A characteristic feature of the norytes is the development of secondary hornblende along certain planes. This shows itself in narrow green bands or lines traversing the rock in various directions and standing out on weathered surfaces. When a number of these are present they give the rock a greenish color.

Almost without exception the norytes are remarkably fresh and unaltered. They are readily seen with the unaided eye to be composed of a clear, glassy feldspar and a reddish-brown or dark hypersthene which may or may not possess a bronzy lustre. In addition to these essential constituents the rock is shown by the microscope to contain a little accessory diallage, together with magnetite, apatite and secondary hornblende. The magnetite is by no means abundant and is often absent from the sections.

The feldspathic constituent is *bytownite* which was found to be slightly more basic than that of the diorytes. It gave extinction angles as high as —22° on oP(001)and —31° on $\infty P \breve{\infty}$ (010). The specific gravity as determined by the Thoulet solution was 2.74. This mineral seldom exhibits crystal outlines but occurs in rounded or irregular grains. As in the diorytes the feldspar is commonly finely striated, though in some cases these twinning lamellæ are wanting. Abundant inclusions, like those so characteristic of the plagioclase of the gabbros, are usually found.

The *pyroxene* is represented almost wholly by the orthorhombic variety, hypersthene. This occurs in grains that are more or less rounded and often elongated in the direction of the vertical(c)axis. The most striking characteristic of this constituent is its marked and often brilliant trichroism. The ray vibrating parallel to the brachydiagonal axis ($\mathfrak{a}$ ray) is reddish brown; that parallel to the macrodiagonal axis ($\mathfrak{b}$ ray) is light greenish yellow; while the one vibrating parallel to the vertical axis ($\mathfrak{c}$ ray) is green. There is a well developed cleavage parallel to the unit prism, and in addition distinct partings parallel to the macropinacoid and brachypinacoid. These show themselves in basal sections as two sets of cracks at right angles to each other and forming angles of 45° with the cleavage lines.

Sections in prism zone showed an extinction parallel to these lines.

Pieces cut parallel to the macropinacoid give in converged polarized light two optic axes and a bisectrix in the field, showing that the brachydiagonal axis is the acute bisectrix and that the mineral is positive. These optical properties establish the fact that this is hypersthene and not enstatite, bronzite or diallage. The specific gravity is 3.50.

The inclusions, to which the hypersthene owes its bronzy, metallic lustre, are commonly quite abundant but may be entirely absent. They do not differ from those so often described as occurring in this mineral.

Diallage is usually present in the norytes as an accessory constituent. It is readily distinguished from hypersthene by its lack of pleochroism. It occurs better crystallized than the latter mineral, being found in irregular grains which have a green color in transmitted light. In a specimen from near the Mount Hope church the diallage formed large porphyritic crystals with a prismatic habit, imbedded in a groundmass of hypersthene and feldspar. The specific gravity is 3.28.

The other accessory constituents are magnetite and apatite. The former is not always present and is usually not very abundant.

Metamorphic changes in the norytes. For the most part these rocks have undergone but little alteration. The most noticeable change is the one already mentioned, namely, the transformation along certain planes of the pyroxene into hornblende. In the hand specimen these planes appear as narrow green bands or lines traversing the rock in various directions, often parallel, and when examined under the microscope they are seen to have been formed by the alteration of the original constituents. The lines cross the slide from one side to the other, cutting across many individuals both of the pyroxene and bytownite. Along these zones the hypersthene has been changed into a colorless, or light green, fibrous hornblende. A narrow band of this secondary hornblende frequently passes through several hypersthene individuals which are elsewhere entirely unaltered. The feldspar is also transformed along these lines into a greenish mineral resembling chlorite. Occasionally small patches of zoisite are developed. Where these

planes have cut across twinning lamellæ it was observed that no displacement of these had taken place and hence there could have been no shearing or slipping. The minerals traversed by the planes show no evidence of having been shattered. The alteration seems, in all cases, to have taken place along certain planes of stress produced by dynamic forces. Along these planes the rock has been subjected to a strain which has resulted, not in the mechanical deformation of the constituents, but in the change of their mineralogical character.

In the same rock the hypersthene is sometimes surrounded by a double rim of hornblende, the inner portion colorless, the outer green and more compact.

Another metamorphic change in the noryte is the alteration of the feldspar into saussurite. In the study of these saussuritized rocks it is usually impossible to determine whether the original type was a gabbro or noryte, since all the pyroxene has been transformed into hornblende. In a specimen collected on the west side of Octoraro creek just south of the "horseshoe bend" remnants of the hypersthene still remained in the fibrous hornblende, leaving no doubt that in this instance at least the rock was a noryte. The orthorhombic pyroxene had lost much of its color, but was yet slightly pleochroic and contained the characteristic tabular inclusions. The feldspar had been entirely replaced by a whitish or greenish, opaque substance composed almost wholly of zoisite. In thin sections this mineral was colorless, with a rather high index of refraction but low double refraction, the interference colors being sometimes dull gray, more often a beautiful ultramarine blue.

While it is not an uncommon thing for the gabbros to have their feldspar thus altered to saussurite, this is, so far as known, the first instance reported of a like alteration in the norytes. We have here a true saussurite noryte composed of zoisite and partially uralitized hypersthene. It is not improbable that many of the rocks described later as saussurite gabbros are really norytes.

Five varieties of the noryte occur within the area under consideration, namely:

1. Noryte.
2. Porphyritic noryte.
3. Quartz-noryte.

4. Olivine-noryte.
5. Saussurite noryte.

The first named, made up almost wholly of hypersthene and bytownite, is by far the most common type, the other varieties being of rare occurrence.

The porphyritic facies was found near the Mount Hope church and consisted of a rather fine-grained groundmass in which were imbedded large phenocrysts of diallage.

The specimens of quartz-noryte were collected from a boulder near the junction of Stone run and Octoraro creek. It resembles very closely the quartz-noryte found at Mount Hope, near Baltimore, and described by U. S. Grant.* The quartz appears in limpid, colorless, or light blue grains, sometimes with a diameter of one-eighth of an inch (3 millimeters). It is filled with slender, hair-like needles, probably of rutile, though this could not be definitely determined. This quartz has every appearance of being an original constituent and not a product of replacement or infiltration.

The almost entire absence of quartz from the pyroxene rocks of this area is noteworthy. It has already been shown to be an important constituent in the closely associated diorytes. Moreover, the gabbros near Wilmington, Delaware, not more than twenty-five miles to the east, are known to contain an abundance of quartz. But in this region the gabbros and norytes only rarely carry any free silica.

A typical noryte (IV) from one mile west of the Oak Grove schoolhouse was analyzed by Mr. W. G. Hillebrand of the U. S. Geological Survey, with the following results. The rock is very fresh and composed of bytownite and hypersthene with some accessory magnetite.

IV.

SiO_2	48.02	MnO	.18
TiO_2	.23	CaO	11.42
ZrO_2	none	SrO	none
Al_2O_3	20.01	BaO	none
V_2O_3	.02 (019)	MgO	10.05
Cr_2O_3	.03 (027)	K_2O	.05
Fe_2O_3	1.13†	Na_2O	.51
FeO	7.29†	LiO_2	trace
NiO, CoO	.01	H_2O below 105° C.	.10

*Johns Hopkins University Circulars, No. 103, Feb., 1893.
†Subject to correction for influence of possible pyrrhotite.

H_2O above 105° C...	.57	Cl..............................	undet.
P_2O_5.....................	trace	Fl..............................	undet.
FeS_2‡..................	.11 (06 S)§		99.98
CO_2........................	.25	Sp. gr..........................	2 980

HYPERSTHENE-GABBRO.

This rock, as already stated, is intimately associated with the noryte, into which it everywhere passes through the decrease in the amount of diallage present. It is impossible to draw any line between these two types either in their geological occurrence or in their mineralogical composition. They occupy the same area and no attempt has been made to separate them in plotting the distribution of the different rocks. The gabbro is less abundant than the noryte and where it does occur it is always rich in hypersthene. It is to be regarded as a mineralogical facies of the prevalent noryte. Fine exposures are to be seen along the railroad south of Conowingo, where it has been blasted to make room for the track. Outcrops also occur along Octoraro creek above the mouth of Stone run, and in the vicinity of Mount Hope church, while boulders of it are abundant at many points throughout the area, notably along the Harford turnpike for a mile northeast of Reckord and east of Conowingo on the Porter Bridge road.

The gabbro resembles the noryte in color, ranging from light shades in those varieties rich in feldspar to dark colored where the pyroxene is the more prominent constituent. As a rule they are more compact and do not have the crumbly appearance of many of the norytes. In texture they are medium to fine-grained. A very coarse-grained facies of the gabbro was observed a short distance above the paper mill on Octoraro creek, some of the constituents having a length of nearly one inch (26 millimeters).

In the hand specimens the minerals that can be readily distinguished are feldspar, hypersthene, and diallage, while under the microscope the rock is seen to contain some accessory magnetite and apatite. Olivine was found in only two specimens.

The feldspar is bytownite and is in all respects identical with that of the norytes already described. It has been more or

‡Sulphur calculated as FeS_2, but exists as pyrrhotite or other sulphide soluble in HCl

§Perhaps mainly pyrrhotite.

less altered to zoisite and is often wholly changed into saussurite. In this regard it differs from the plagioclase of the associated pyroxene rocks which is as a rule very fresh and unaltered.

It is not necessary to add anything more to the description already given of the diallage and hypersthene. The former mineral is not present in large amount and while it varies considerably it is rarely more plentiful than the orthorhombic pyroxene. The former is by far the most important of the ferromagnesian constituents occurring in these basic rocks. Magnetite is seldom absent and apatite, while frequently found, is by no means abundant.

Olivine is rare in the gabbros and norytes of this region, having been observed in only two specimens, one from the small area northeast of Elkton, the other from near Oak Grove schoolhouse, one and one-half miles northwest of Rising Sun.

Metamorphic changes in the gabbro. The gabbro of this area has undergone considerable alteration which has resulted in the change of its feldspar into saussurite and its pyroxene into hornblende. The metamorphosed rock thus produced is a typical saussurite gabbro. The saussurite is found under the miscroscope to be composed almost wholly of crystals and irregular grains of zoisite. Some good sized patches of the latter gave no evidence, even with the highest power, of being formed of small individuals. On the other hand, the larger masses are frequently seen to be not single crystals but aggregates made up of separate grains and crystals. Prisms of zoisite without terminal faces are quite common. They show the perfect cleavage parallel to the vertical axis, the cross jointing at right angles to this, the parallel extinction and the biaxial interference figure with very small optic angle. The mineral is colorless, has a high index of refraction, weak double refraction, and is optically positive. In thin sections the saussurite is as a rule quite clear and transparent, since the zoisite composing it is in good sized grains and crystals, but occasionally it becomes opaque. As already stated, the pyroxene of these gabbros has been changed into fibrous hornblende. The two chief constituents of the saussurite gabbro are therefore secondary hornblende (smaragdite) and saussurite. Some chlorite and a little secondary quartz are commonly present.

GABBRO-DIORYTE (METAGABBRO.)*

Like the saussurite gabbros these rocks are formed by the metamorphic changes which have gone on in the hypersthene-gabbros, but in this case only the pyroxene has been altered, the greater portion of the feldspar remaining unchanged. There does not appear to have been a very extensive development of the gabbro-dioryte in this area and consequently the rock is not very abundant. Of the few localities where it was observed the best is in the vicinity of the Mount Hope church, one and one-half miles northeast of Rising Sun; it is here found in scattered boulders and also exposed in the railroad cut near by.

The gabbro-dioryte may be distinguished from the true dioryte both by its finer grain and by its dark greenish color. The latter characteristic also serves to separate it from the gabbro and noryte which do not have the greenish tinge imparted by the secondary hornblende when present. The metagabbro is commonly more compact than many of the pyroxene rocks.

In the hand specimen the unaided eye can readily distinguish a clear, usually fresh, colorless or white feldspar and a greenish, fibrous hornblende with a satiny lustre. The microscope shows that some magnetite, apatite and epidote are also present. The feldspar is bytownite as in the original gabbro and does not differ from that already described in connection with that type. It has not suffered much alteration and is as a rule clear and fresh; occasionally, however, a little secondary epidote is developed in the plagioclase. The hornblende is the common green pleochroic variety. It never shows crystal outlines but occurs in fibrous masses or forms aggregates composed of numerous small individuals. When the hornblende is fibrous, as is commonly the case, these individuals are often colorless on the inside and surrounded by a green and more compact border.

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*The term gabbro-dioryte was first employed by A. E. Törnebohm (Neues Jahrbuch f. Min. etc., 1877, p. 391), was later applied by Williams to the secondary diorytes of the Baltimore region, and has since come into quite general use. Recently, however, it has been suggested that for much altered rocks which are of known igneous origin the term "meta" be prefixed to the name of the original rock. In accordance with this usage an altered gabbro would be designated a metagabbro instead of a gabbro-dioryte. (Report of Committee on Nomenclature of Igneous Rocks, appointed by the Director of the United States Geological Survey.)

The formation of hornblende from pyroxene is by no means uncommon and the alteration need not be described here.

DIABASE.

At several points between Rising Sun and Sylmar station, on the state line, boulders of diabase were found. These doubtless belong to the dike described by H. C. Lewis and traced by him as far as the Maryland line which it crosses probably a little west of Sylmar.* The dike extends in a southwest direction through southeastern Pennsylvania, where it was followed for a distance of seventy miles. The width at some points was found to be one hundred feet. Its age is thought by the above writer to be late Triassic, since it cuts rocks of the latter age.

Diabase boulders are quite abundant just across the railroad east of Rising Sun and south of the wagon road; they are also found in the fields south of the railroad at other points between here and Sylmar. G. P. Grimsley states that a diabase dike was traced for nearly a mile south of the town of Liberty Grove. Since these scattered boulders are in general arranged along a line having a northeast-southwest direction and extending from the state line to the vicinity of the town above mentioned, the evidence seems to be sufficient to warrant the representation of it which has been made upon the map.

The rock is a fine-grained diabase which has a metallic ring when struck with the hammer. The weathered surface is covered with a thin coating of red clay. Under the microscope the rock is seen to be composed of lath-shaped crystals of feldspar, irregular grains of augite and a little magnetite.

PYROXENYTE.

With a decrease in the amount of feldspar the noryte and hypersthene-gabbro pass over into rocks composed wholly of pyroxene. These pyroxenytes are common at many points along the border next the serpentine, where they are closely associated with the latter rock and also with the peridotyte. Intermediate types between the pyroxenyte and noryte are often found. Among the localities for the pure pyroxene rock may be mentioned the following: in the vicinity of Oakwood, especially just east of town at the Mount Pleasant academy;

*Proc. Amer. Philos. Soc., May 15, 1885, pp. 438-456.

along the serpentine border south of Rock Springs; about Sylmar and the Mount Hope church; near the point where the west branch of Stone run crosses the state line, and along the railroad near the section-house below Conowingo. At the two last named localities the rock is exposed in outcrops and is associated with peridotyte and serpentine. Near Conowingo it forms dikes in the noryte. These pyroxenytes are coarse, granular aggregates composed of rounded grains of diallage and hypersthene. In a hand specimen it is easy to distinguish these two minerals which make up the bulk of the rock. The diallage is dark green, almost black, while the hypersthene is commonly a reddish brown. The constituents often reach a length of from one-quarter to one-half an inch (7-13 millimeters) and sometimes more. They vary in color from the dark green, almost black rocks rich in diallage to dark purple or reddish brown ones composed almost entirely of hypersthene.

The hypersthene resembles that already described as occurring in the norytes and gabbros, though in the pyroxenytes the tabular inclusions were not observed. The mineral is readily distinguished under the microscope by its brilliant trichroism.

The diallage is green in transmitted light and shows no pleochroism. The columnar structure so characteristic of bronzite and enstatite is often present in great perfection, the mineral being composed of thin columns or prisms grown closely together, which give the diallage a coarsely fibrous appearance. The prismatic cleavage is well developed but even more noticeable is the very distinct parting parallel to $\infty P \bar{\infty}$ (100). Small cleavage pieces parallel to the orthopinacoid gave in converged polarized light an optic axis which had an eccentric position in the field. The presence of this interference figure, together with the inclined extinction (40°) shows the mineral to be diallage and not bronzite or enstatite. Basal sections also show an optic axis surrounded by several bright rings.

The only other constituents besides those already given are an occasional grain of magnetite and sometimes a little feldspar. As the latter increases in amount the rock graduates into a noryte. A common intermediate type is a pyroxene rock very rich in hypersthene and in which the plagioclase forms about one-tenth of the entire mass.

Two varieties of pyroxenyte occur in northeastern Maryland, namely, a hypersthene-diallage rock (websteryte) and a pure hypersthene rock (hypersthenyte.) The latter, which has a coarsely granular texture, is the more abundant, being found at a number of different points, but especially in the vicinty of Oakwood and a short distance south of Conowingo. At the former locality the hypersthenyte seems to occur as a facies of the noryte, along the border between the latter and the serpentine, while at the last named locality the rock forms a dike or dikes in the noryte. In places the hypersthenyte contains some olivine and thus passes into peridotyte. The websteryte is found near Oakwood and at various points, but perhaps the best locality for this rock is one and a half miles west of Sylmar. At this same place there is an outcrop of peridotyte along the road near the crossing of the west branch of Stone run. Like the other pyroxenyte type the websteryte is frequently found near the edge of the noryte mass, closely associated with the serpentine. The rock is a very coarse-grained aggregate, the allotriomorphic individuals often measuring one-quarter of an inch (6 to 7 millimeters) in diameter. Both varieties of pyroxenyte are remarkable for their freshness, many of them having undergone no alteration whatever.

Pure pyroxene rocks, which are quite abundant in Maryland, were first described from here by G. H. Williams* who recognized two well marked types as occurring within the state, namely, a hypersthene (or bronzite)-diallage rock and one composed of the same orthorhombic pyroxene and diopside. To these two types a third must now be added, namely, one composed almost wholly of hypersthene—the hypersthenyte.

The first type above mentioned occurs in Baltimore, Harford and Cecil counties, Maryland, and in Chester county, Pennsylvania. The latter occurrence is described by F. D. Chester, who states that the rock consists mainly of bronzite and diallage which are usually much altered.† The second type, the bronzite-diopside aggregate, occurs near Hebbville P. O., Baltimore county, and resembles the pyroxenyte from near Webster, North Carolina, assumed as the type locality bv Williams.

*Amer. Geol., July, 1890, pp. 35-49.
†Ann. Rept. Geol. Surv., Penn., for 1887, p. 95, 1889.

Rocks composed largely of pyroxene and containing neither feldspar nor olivine have been mentioned by Hunt from Rougemont and Montarville, Canada;* by J. D. Dana and G. H. Williams from the Cortlandt series of New York;† by Hutton from the Dun mountains in New Zealand;‡ by Turner from Mount Diablo, California, where the pyroxenyte is associated with peridotyte and gabbro;§ and by Hatch from Madagascar.¶

A word should perhaps be added concerning the usage of the term pyroxenyte. The name was first used by T. Sterry Hunt, who applied it both to intrusive rocks composed mostly of pyroxene,‖ and to nests of pyroxene in the Archean limestones of Canada and New York.**

G. H. Williams in 1890 proposed that the term pyroxenyte be employed to designate those igneous rocks free from both feldspar and olivine and this is now the generally accepted usage. Pyroxenytes composed wholly or chiefly of hypersthene, which are found at various localities in Cecil county, are of rare occurrence. Such a rock with very little diallage was found by Wülfing in blocks on Monte Matterone, near Bavano, Italy, and Adams notes rocks of this variety containing a little bytownite, from Shipsaw and Ha-Ha-Bay, Canada. At the latter locality the specimens carried some hornblende and olivine.° So far as known these are the only localities outside of Maryland where the hypersthenyte is found.

The name hypersthenyte was first applied to rocks of the gabbro series composed chiefly of orthorhombic pyroxene and basic plagioclase and it is still sometimes employed in that sense. But the term noryte is now more commonly used for such rocks and hypersthenyte is reserved for those pyroxenytes composed largely of hypersthene.

As already stated, these pyroxenytes are as a rule remarkably fresh and unaltered. But along the serpentine border and elsewhere within the area smaragdite and other fibrous amphibole rocks are very common and these have in all probability originated from the pyroxenyte. When this alteration is

*Geol. of Canada, 1873, p. 667.
†Amer. Jour. Sci., 3rd Series Vol. XX, p. 1894, 1897.
‡Trans. Roy. Soc. New South Wales, 1889, p. 153.
§Bul. Geol. Soc. Amer., Vol. II, 1891, p. 383.
¶Quart. Jour. Geol. Soc., Vol. XLV, 1889, p. 345.
‖Geol. of Canada, 1863, p. 667.
**Catalogue of the Canadian Rocks at the London Exhibition, 1862; and Geological Survey of Canada. Report for 1863-66, pp. 185, 226.
°Rosenbusch, Mikroskopische Physiographie, Vol. II, p. 361, 1896.

still in its early stages cores of pleochroic hypersthene may yet be seen surrounded by secondary hornblende, but commonly the former mineral has entirely disappeared. More or less iron oxide separates out during the change and is scattered through the mass in small grains of magnetite.

The following analysis (V) of a fresh and typical websteryte from Oakwood was made by Mr. W. F. Hillebrand, of the United States Geological Survey. The rock is a very coarse-grained aggregate of hypersthene and diallage. This analysis agrees very well with those given by G. H. Williams* for the two varieties of websteryte from Baltimore county.

V.

SiO_2	53.21	MgO	20.78
TiO_2	.26	K_2O	.07
ZrO_2	trace	Na_2O	.11
Al_2O_3	1.94	Li_2O	trace
V_2O_3	.03 (034)	H_2O below 105° C.	.14
Cr_2O_3	.20	H_2O above 105° C.	.87
Fe_2O_3	1.44	P_2O_5	trace
FeO	7.92	FeS_2†	.03 (02 S)‡
NiO, CoO	.03	CO_2	.10
MnO	.22	Cl	undet.
CaO	13.12	Fl	undet.
SrO	none		100.47
BaO	none	Sp. gr.	3.34

PERIDOTYTE.

This rock forms several small areas within the noryte-gabbro belt and also occurs at one point along the border between this and the serpentine. The largest mass is one and a half miles northeast of Rising Sun, at the Mount Hope church. The area extends in a northeast direction and is less than one-quarter of a mile long. The rock, which outcrops at numerous points, has weathered in such a way that it presents a very rough and pitted surface. Associated with the peridotyte is some pyroxenyte and smaragdite rock. Another area of much altered peridotyte is found one and a half miles northwest of Rising Sun near the Oak Grove schoolhouse. Peridotyte occurs as a dike outcropping along the railroad just below

*Am. Geol. July, 1890, p. 35.
†Sulphur calculated as FeS_2, but exists as pyrrhotite or other sulphide soluble in HCl.
‡Perhaps mainly pyrrhotite.

Conowingo and is also exposed a mile and a half west of Sylmar, near the state line, associated with pyroxenyte. These two types are in fact generally closely associated. While the peridotytes are at present not very abundant there is every reason for believing that much of the serpentine has been derived from them and hence that at one time they covered much or all of the large area now occupied by the latter rock.

The rocks under discussion are dark brown or almost black, and, while they are as a rule coarse-grained, they vary widely in structure and appearance. The variety from the Mount Hope church locality exhibits well the peculiar mottled or poikilitic structure. There are large, brightly reflecting cleavage surfaces of pyroxene dotted over with small grains of olivine, largely changed to serpentine, and it is these dull spots which give the rock its speckled appearance. Under the microscope the pyroxene extinguishes uniformly over large areas. Another variety from the dike below Conowingo has a porphyritic structure caused by phenocrysts of pyroxene scattered through a groundmass composed of olivine and accessory hypersthene. This groundmass readily changes into serpentine through which are scattered the yet unaltered pyroxenes. Again, the rock may have a more or less banded appearance, as in the state line outcrop. This structure is produced by layers of compact, serpentinized olivine, alternating with other granular layers composed of pyroxene and some comparatively fresh olivine.

The pyroxenic constituents of these peridotytes are hypersthene and diallage. Associated with these is more or less olivine and occasionally a little feldspar. In one specimen the latter had changed into zoisite. The pyroxene is readilv distinguished by the bright cleavage surfaces and reddish-brown or dark green colors. The diallage does not differ from that already described in the pyroxenytes. In thick sections it has a green color and shows no pleochroism. The columnar structure is well developed and many individuals include rounded grains of olivine.

The orthorhombic pyroxene is represented by hypersthene. Cleavage pieces of this parallel to the macropinacoid show in converged polarized light two axes and a bisectrix in the field. The mineral is optically positive, the brachydiagonal axis being the acute bisectrix. The positive character of the mineral

together with the small optic angle and well marked trichroism indicate beyond any doubt that it is hypersthene and not enstatite or bronzite. The hypersthene sometimes occurs in porphyritic crystals measuring from a quarter to half an inch in length (6 to 13 millimeters). The olivine is as a rule not distinguishable with the unaided eye except where it appears as dull spots on the cleavage surfaces of the pyroxene. It occurs in well rounded grains which have commonly been more or less altered into serpentine. The manner in which this change takes place does not differ from that so often described. The fibres of serpentine are arranged at right angles to the cracks which form a network traversing the olivine in all directions. The alteration is accompanied by the separation of considerable iron.

Feldspar is occasionally present in these rocks in small amount. As already stated, it had in one specimen been altered to zoisite. The only other mineral observed was a little secondary fibrous hornblende. As a rule the pyroxene found in the peridotytes is quite fresh and unchanged. Many of the latter rocks which have undergone considerable alteration into serpentine still contain scattered through their mass good sized crystals of hypersthene or diallage, which show bright cleavage surfaces. The porphyritic structure of the peridotyte appears to be the exception rather than the rule in this area, whereas in the Baltimore region Williams states that all the olivine rocks exhibit this structure.*

Two distinct types of peridotyte appear in northeastern Maryland, namely, a diallage-olivine rock or wehrlyte, and a hypersthene-olivine rock or harzburgyte (saxonyte). The former usually contains a little accessory hypersthene and the latter may carry diallage in small amount. The two types thus merge into each other and no sharp line of separation can be drawn between them.

The harzburgyte appears to be exceptional in containing hypersthene instead of enstatite or bronzite, which are the orthorhombic pyroxenes commonly present in this type. A peridotyte of this kind with some hornblende and biotite is described by Cross as occurring in Cottonwood gulch, Custer county, Colorado.† The hypersthene was only slightly pleo-

*Bul. U. S. Geol. Surv., No. 28, p. 50, 1886, and Amer. Geol., July, 1890, p. 28.

†Proc. Colorado Scientific Society, 1887, p. 228.

from Angel island in San Francisco bay, which has originated from a rock composed wholly or mainly of diallage. In this instance the alteration seems to have been directly to serpentine and not through the intermediate hornblende stage. Other examples of serpentine derived from pyroxenyte rocks are mentioned by Drasche* from the Tyrol and Ireland; by Berwerth† in serpentines near Rosignano and Castellina Maritina, south of Pisa, Italy, and by several other writers.

The following analysis (VI) of a deep green, translucent variety of serpentine from the old Broad Creek quarry in northeastern Harford county was made some years ago by F. A. Genth of the University of Pennsylvania.‡

VI.

SiO_2	40.06	MgO	39.02
Al_2O_3	1.37	H_2O	12.10
Cr_2O_3	0.20	Fe_3O_4	3.02
NiO	0.71		
FeO	3.43		100.00
MnO	0.09	Specific gravity	2.668

VEINS AND DIKES.

The basic and ultra-basic rocks of northeastern Maryland are cut by numerous pegmatyte dikes and quartz veins. In addition to these there is the diabase dike already mentioned. The latter extends in a southwest direction through southeastern Pennsylvania and into Maryland, probably crossing the line in the vicinity of Sylmar. Blocks of diabase were found at various points south of the railroad between the latter town and Rising Sun, and though no outcrops were observed the boulders were in general distributed along a line having the same course as the dike where it was traced farther north. Grimsley states that south of Liberty Grove a diabase dike was traced for nearly a mile, and it is probable that this is part of the same one. H. C. Lewis gives the age as late Triassic or early Jurassic, since in Pennsylvania it cuts through shales of the former age, and must, therefore, have been formed at the end of that period or at the beginning of the next.

Cutting the norytes south of Conowingo and occurring also at other points are dikes of peridotyte and pyroxenyte. One

*T. M. P. M., Vol. I, p. 10, 1871.
†T. M. P. M., Vol. IV, p. 238, 1876.
‡Geological Report of the Md. "Verde Antique" Marble and other Minerals on the lands of the Havre Iron Co., in Harford County, Md., by Prof. F. A. Genth. 1875.

of these can be seen at the section house just below the town, while not over twenty feet north of it there is a dike of pegmatyte. The peridotyte has been partially changed to serpentine.

A noticeable feature of this region is the abundance of white vein quartz, fragments of which strew the fields in many places or are seen mingled with the gabbro and noryte boulders collected in the stone walls everywhere so common in the area. At some points these quartz fragments are so numerous as to form no inconsiderable proportion of the boulders. For the source of this material we must doubtless look to the veins of quartz which have cut not only the basic rocks but also the gneisses bordering upon these to the east and south. The number and extent of these veins is partially indicated by the many fragments derived from them.

The quartz veins have in all probability been formed by lateral secretion, the silica having been leached out of the surrounding rocks and deposited by percolating waters in fissures and crevices produced by orographic movements. Wherever the rocks are well exposed, as along the Susquehanna, they are seen to be traversed by gashes and cracks which have been filled with this secondary quartz, the latter often forming small lens-shaped masses.

The pegmatyte veins* are of special interest and importance since they supply large quantities of feldspar and quartz ("flint") to the potteries of Maryland, New Jersey and Delaware. These dikes, which are often of considerable extent, are found cutting not only the norytes and gabbros but also the serpentines. They have a northeast-southwest direction, corresponding to the strike of the schists and the foliation of the massive rocks where the latter has been developed by pressure. Two of these coarse granitic veins are well exposed along the Susquehanna, one below and another above Conowingo. The former appears less than one-quarter of a mile south of the station, where it is well exposed along the railroad. This dike, which has a width of eight feet, is composed of granite with seams of coarse pegmatyte and is bordered on either side by a saussurite gabbro. The vein a short distance above the town

*All the acid dikes or veins of this region are here referred to as pegmatyte since they are formed largely of very coarse granite. While they are not infrequently composed of true granite, into which the pegmatite passes, it is convenient to have a general term which shall include all those dikes composed of quartz-feldspar rock.

is much more extensive, having a width of three hundred feet or more. In some parts it is made up largely of quartz. The rock is usually a rather fine-grained granite traversed by numerous veins of pegmatyte. Here and there the muscovite forms sheaf-like aggregates, or it may occur in well developed hexagonal plates. The peculiar intergrowth of the quartz and feldspar, giving rise to graphic granite, was also found in this locality. Good sized crystals of tourmaline are occasionally present. Neither of these dikes could be traced very far back from the river.

Three large pegmatyte veins appear along Octoraro creek between the paper mill and the state line. On the hill just above the mill one of these has been worked as a quarry and furnishes a good quality of building stone. Most of the rock at this point is a medium fine-grained granite composed of quartz, microcline, muscovite, and some biotite. The vein has a width of ninety feet and is in places pegmatitic. The second is about three-quarters of a mile above the mill and the third, which is one hundred feet wide, occurs close to the Maryland line. The last is of special interest, since it was found to contain many fragments of the country rock, often of considerable size and not infrequently three feet in diameter. They are composed of much altered and saussuritized gabbro resembling that occurring in the vicinity. In fact, this saussuritized gabbro seems, in many cases at least, to be closely associated with the pegmatyte veins, and it is possible that these have had something to do in producing the alteration of the original rock.

The pegmatytes are composed of white or pink microcline, quartz, muscovite, a little albite and occasionally biotite. Tourmaline is a somewhat rare constituent.

That the pegmatytes are of eruptive origin can scarcely be doubted. The best evidence of this is furnished by the fragments of the country rock found included in these veins. These must have been torn from the side walls as the molten magma was intruded into the fissures. The composition of these coarse granites, differing so widely from that of the norytes and serpentines in which they occur, is also an indication that they are intrusive or have at least not been formed by circulating waters deriving their materials from the surrounding rocks. They are rich in alkalies and do not appear

to be affected in their composition by the nature of the enclosing mass.

RELATIONS OF THE DIFFERENT ROCK TYPES.

Having considered somewhat in detail the different rock types represented in the area it remains to discuss the relations existing between them. It has been shown that they are more or less closely associated in their geological occurrence and that many of the types are connected by intermediate varieties. The rocks grow successively more and more basic from tne south toward the north. If one starts from Rowlandsville or from a point one mile north of Colora and travels north to the Pennsylvania line he passes over in succession biotite-granite, quartz-mica-hornblende-dioryte (tonalyte), dioryte and quartz-dioryte, hypersthene-gabbro and noryte and serpentine. The distance traversed in thus passing from the acid to the basic and ultra-basic types is sometimes two miles and never exceeds three miles.

GEOLOGICAL RELATIONS OF THE DIORYTES AND GRANITES.

The close relationship existing between the dioryte and granite is evident both from their association in the field and from the study of a large number of sections made from specimens collected at many points in the intermediate zone. As already stated, the diorytes form a belt varying in width from one to one and a half miles, bordering the granite on the north and lying between that and the gabbro. It was everywhere found impossible in the field to draw any sharp line of separation between the granites and diorytes, and along quite a well defined intermediate belt there is a gradual passage from one to the other. This transition is even more apparent from the microscopical study of a large number of thin sections which show a change in the mineralogical composition of the rocks. It has already been stated that there are two well marked varieties of the dioryte, one a quartz-mica-hornblende-dioryte or tonalyte and the other a quartz-dioryte. The former, which is very granitic in appearance, is confined almost entirely to the southern portion of the area next to the granite, and forms a connecting type between that rock and the quartz-dioryte, while the latter is found along the northern border. By an increase

in the amount of hornblende and a corresponding decrease in the biotite, the tonalyte passes into a quartz-dioryte. On the other hand, by a decrease in the amount of hornblende and a corresponding increase in the biotite it passes over into the biotite-granite of the Rowlandsville area. This latter rock, as shown on a later page, is chemically very closely related to the diorytes and can in fact be considered as a biotite-dioryte. These intermediate varieties between the granites and the true diorytes are of common occurrence and cover considerable territory.

There is also a change in the feldspar as the rock becomes poorer in silica and richer in hornblende. In the biotite-granite the feldspar is oligoclase along with a little orthoclase; in the tonalyte it is an acid labradorite, while in the true diorytes this constituent is represented by an acid bytownite. Nowhere was any line of contact observed between the granites and diorytes, and careful search failed to reveal the presence of any eruptive contact, such as that described by Grimsley along Octoraro creek in the vicinity of Porter Bridge. The granite does contain, it is true, the dark, fine-grained, granitic segregations such as those mentioned by that writer. But no reason was found for regarding some of these more basic patches as segregations and some as inclusions. Nor did these change in appearance or composition as the dioryte border is approached, and no increase in their number or size was observed in that direction. In the absence of any better evidence of an eruptive contact than is afforded by these basic segregations, which do not resemble inclusions of dioryte or gabbro, there would seem to be slight ground for supposing there is here any such contact. Careful search failed to reveal the presence of any dikes or apophyses of either rock.

GEOLOGICAL RELATIONS OF THE DIORYTES, GABBROS AND NORYTES.

Bordering the diorytes on the north and closely associated with them are the norytes and hypersthene-gabbros. It was found possible to distinguish two kinds of hornblende-feldspar rocks, one original and commonly carrying considerable quartz, the other secondary and produced by the alteration of the gabbro. In the latter (metagabbro or gabbro-dioryte), quartz was usually absent or present only in small amount,

the hornblende more or less fibrous, sometimes nearly colorless in transmitted light, and derived from the pyroxenes. These metagabbros have not been extensively developed in this region and are much less abundant than the true dioryte. As a rule the original hornblende rocks differ in texture from the pyroxene rocks, the former being considerably coarser and resembling the granites in size of grain.

The norytes make up the larger part of the area occupied by the pyroxene rocks. They are abundant not only in Cecil county, but also across the Susquehanna in Harford county, where they are found at many points. The hypersthene-gabbro is probably a facies of the noryte and the two types merge into each other wherever they occur. But though the pyroxene and hornblende rocks are so intimately associated in their geological occurrence, no intermediate varieties connecting the two were found in Cecil county, such as exist between the diorytes and granites. An original hornblende gabbro is stated by G. H. Williams* to occur in Harford county, and is said to pass into augite or hypersthene-dioryte, but no such intermediate types were observed east of the Susquehanna.

GEOLOGICAL RELATIONS OF THE NORYTES AND GABBROS TO THE ULTRA-BASIC ROCKS.

The non-feldspathic rocks occur as lens-shaped masses and as dikes within the noryte and are also found along the border next to the serpentine, where they seem to represent a more basic facies of the noryte. The peridotyte and pyroxenyte are closely associated in their geological occurrence and the one type sometimes graduates into the other. This relationship is well shown in the railroad cut just below Conowingo where both of the ultra-basic rocks are found together in the same dike. The olivine is sometimes confined to particular portions of the rock, occurring abundantly in certain layers or bands and being almost absent from others. There results from this arrangement a banded rock made up of alternating layers of nearly black serpentine and of little altered pyroxene—a structure mentioned by Williams in the peridotytes of Baltimore county.†

The pyroxenytes are intimately related to the norytes with which they are connected by intermediate types. All varieties

*Johns Hopkins Univ. Circulars, No. 65. Vol. VII, 1888, p. 62.
†Bull. U. S. Geol. Surv., No. 28, 1886, p. 57.

are found between those pyroxene rocks rich in feldspar, the latter mineral forming over one-half of the mass, and those without a trace of that constituent. A common type is one containing less than one-quarter of its bulk of plagioclase, the rest being formed of hypersthene.

The mode of occurrence of the non-feldspathic rocks indicates that they are younger than both noryte and gabbro. The peridotyte area near Mount Hope church, for examole, is plainly an intrusive mass in the older noryte rock, and their more recent age is even more apparent in the case of the dikes.

It has been shown that the serpentine undoubtedly originated from the alteration of the peridotytes and pyroxenytes so closely associated with it. The gradual passage of the latter into serpentine is well exhibited in manv of the less altered specimens, where all stages of the change can be traced. These ultra-basic types must therefore have occupied at one time a much larger area than at present and covered the district now composed of serpentine.

A somewhat different alteration product of the pyroxenytes, and one which has perhaps resulted more frequently from their transformation, is an amphibole rock. This is composed of a fibrous hornblende, sometimes green in color (smaragdite), sometimes gray. The different individuals occasionally have a core of unaltered pyroxene, which indicates that the mass was originally composed of this mineral. These secondary amphibole rocks are abundant throughout the area, but appear to be especially common near the serpentine border where, as already stated, the pyroxenytes often occur.

CHEMICAL RELATIONS OF THE ROCKS OF THE SERIES.

The chemical relations of the rocks of the district are shown in the following table in which the analyses are arranged in the order of diminishing acidity.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
SiO_2...........	73.69	66.68	58.57	55.16	44.04	48.02	53.21	40.06
TiO_2...........	....	0.50	1.41	0.64	2.24	0.23	0.26	....
ZrO_2...........	....	....	0.09	0.02	0.10	none	trace	....
Al_2O_3.........	12.89	14.93	16.10	17.51	20.01	20.01	1.94	1.37
V_2O_3..........	....	....	0.02	0.04	0.05	0.02	0.03	....
Cr_2O_3.........	....	....	none	trace	none	0.03	0.20	0.20
Fe_2O_3.........	1.02	1.58	2.89	2.62	4.22	1.13	1.44	....

FeO	2.58	3.24	6.12	5.83	8.61	7.29	7.92	3.43
NiO, CoO	....	....	none	0.01	0.01	0.01	0.03	0.71
MnO	....	0.10	0.18	0.15	0.28	0.18	0.22	0.09
CaO	3.74	4.89	7.39	8.50	11.68	11.42	13.12	....
SrO	....	trace	trace	trace	none	none	none	....
BaO	....	0.08	trace	trace	none	none	none	....
MgO	0.50	2.19	2.33	4.35	5.01	10.05	20.78	39.02
K_2O	1.48	2.05	1.01	1.08	0.15	0.05	0.07	....
Na_2O	2.81	2.65	2.11	1.83	1.24	0.51	0.11	....
Li_2O	....	trace	trace	trace	trace	trace	trace	....
H_2O below 105° C.	1.06	0.16	0.21	0.18	0.11	0.10	0.14	12.10
H_2O above 105° C.	....	1.09	1.27	2.01	1.90	0.57	0.87	
P_2O_5	....	0.10	0.37	0.21	0.52	trace	trace	....
FeS_2	....	....	trace	0.03	0.25	0.11	0.03	....
CO_2	....	....	none	none	none	0.25	0.10	....
Cl	....	....	undet.	undet.	undet.	undet.	undet.	....
Fl	....	....	undet.	undet.	undet.	undet.	undet.	Fe_3O_4 3.02
	99.74	100.32	100.07	100.17	100.42	99.98	100.47	100.00
Sp. gr.	....	....	2.89	2.90	3.03	2.98	3.34	2.66

I. Granite from the Port Deposit quarries.
II. Biotite-granite from the railroad cut at Rowlandsville.
III. Quartz-mica-hornblende-dioryte. Near the foundry on Stone run.
IV. A more basic variety of the same. Porter Bridge on Octoraro creek.
V. Hornblende-dioryte poor in quartz. Three-quarters of a mile northwest of Rising Sun.
VI. Noryte. One mile west of Oak Grove schoolhouse.
VII. Websteryte. Oakwood.
VIII. Serpentine. Broad creek quarry in northeastern Harford county.

Analyses I and II are taken from G. P. Grimsley's paper on the granites of Cecil county.* I. was made by Mr. William Bromwell in the chemical laboratory of the Johns Hopkins University; II.-VII. were made by W. F. Hillebrand, of the United States Geological Survey, and VII. is by F. A. Genth.

It will be observed that the rocks of the series range in composition from that of a granite to a pyroxenyte and serpentine. A comparison of these analyses shows that as the silica decreases there is an increase in the magnesia, the latter constituent being especially characteristic for rocks of this character. The alumina increases from the most acid member of the series

*Jour. Cincinnati Soc. Nat. Hist., Vol. 17, pp. 59-67; 78-114. Cincinnati, 1894.

to the websteryte when it drops suddenly from 20.01 per cent to 1.94 . With diminishing silica there is also a decrease in the alkalies, but a decided increase in the lime. The presence of vanadium in these rocks is worthy of notice. Number II., which is given by Grimsley as an analysis of a biotite-granite, corresponds very closely with the analyses of quartz-mica-dioryte and of tonalyte as given by Rosenbusch.* Its rather low silica content, its high percentage of lime (4.9) and relatively low percentage of potash (2.05), together with a large amount of magnesia, all seem to indicate a relationship with the diorytes rather than the granites. From the point of view of its chemical composition it should probably be considered a quartz-mica-dioryte rather than a granityte. But what is of special interest in the present discussion is the fact that this rock lies on the border between the diorytes and granites.

It will be seen from analyses III., IV. and V., that there are two types of dioryte, a more acid quartz-mica-hornblende-dioryte and a basic hornblende-dioryte. The former is poorer in silica than the typical tonalyte, though it agrees with the latter in mineralogical composition. The hornblende dioryte of number V. contains only a small amount of quartz and is somewhat more basic than much of the true dioryte of the area, which is rich in quartz. It will be observed that the tonalytes (III., IV.) approach the granite in composition, while the analysis of the dioryte proper (V.) corresponds quite closely with that of the noryte (VI.), the only essential difference between the two being in the magnesia.

If the basic eruptives of northeastern Maryland are compared with those occurring in the vicinity of Baltimore on the one side, and with those of Wilmington, Delaware, on the other, certain resemblances and differences are at once apparent. The area under discussion, occupying as it does an intermediate position between the two, might be expected to exhibit certain features common to both. Perhaps the most marked characteristic of the rocks of all three areas is the abundance of hypersthene present. This is especially true in northeastern Maryland and Delaware, where this constituent plays a more important role than the diallage, the latter being present only in small amount. In both the Baltimore and Cecil-Harford areas

*Elemente der Gesteinslehre. 1898. p. 140.

peridotytes and pyroxenytes are found associated with the gabbros and norytes, where they have by their alteration produced extensive masses of serpentine.

In both the Delaware and Cecil-Harford areas the basic rocks are often rich in quartz. But in the former state this is found in the gabbros, while in Maryland it is the diorytes that carry the quartz, the latter mineral being almost absent from the norytes and gabbros. It has been found at only two points, namely, in the vicinity of Mount Hope, Baltimore county, and the junction of Stone run and Octoraro creek. Brown hornblende occurs as an accessory constituent in the other areas, but was not observed in any of the rocks under discussion. Olivine is equally rare in all three districts. Biotite is found in the gabbros near Wilmington but is lacking in the Maryland rocks.

The area under discussion differs in certain respects from those lying to the east and west of it. One distinguishing feature is the abundance of dioryte, usually rich in quartz, and its passage into the granites. Another is the comparatively slight development of gabbro-dioryte from the gabbro, an alteration which has taken place on a large scale in the other two areas. Though many of the gabbros and norytes show the early stages of this change, those rocks are comparatively rare in which the pyroxene has been completely altered to hornblende. This does not include the saussurite gabbros which have had both their original constituents changed into secondary products. A third difference is the presence in this area of many large granite and pegmatyte dikes in the noryte and serpentine Some large blocks of pegmatyte were found at one point in the Baltimore area* but this was the only instance of such an occurrence within the basic eruptives of that district.

RÉSUMÉ AND GENERAL CONCLUSIONS.

In northeastern Maryland a series of acid and basic eruptive rocks has broken through the ancient gneisses (pre-Cambrian?). The following types are represented: biotite-granite, dioryte, quartz-dioryte, quartz-mica-hornblende-dioryte (tonalyte), noryte, hypersthene-gabbro, pyroxenyte, peridotyte, and serpentine. The basic and ultra-basic varieties have been cut

*Bul. U. S. Geol. Survey, No. 28, 1886, p. 25.

by extensive dikes of granite and pegmatyte which have a northeast-southwest direction and have no apparent connection with the granite mass to the south. Near the eastern end of the main belt there is a Triassic diabase dike which has been traced for a distance of seventy miles through southeastern Pennsylvania and Maryland.

Where the granites border the area of basic eruptives on the south there is a gradual passage of the granite into dioryte and no line of separation can be drawn between them. The noryte forms the bulk of the main mass of basic rocks and the hypersthene-gabbro is to be regarded as a facies of the noryte. The latter rock is in some places found to graduate by intermediate types into pyroxenyte and the two occur intimately associated in the field. The pyroxenytes and peridotytes are closely related and they commonly occur together, in one instance both being found in the same dike.

A study of their geological relations and occurrence makes it evident that the rocks of this area were not all formed at the same time. It is probable that the region was the scene of eruptive activity for a considerable period, during which the different types were produced. The norytes and gabbros appear to have been the first to be erupted. The diorytes were probably formed at the same or nearly the same time. The absence, in Cecil county, of intermediate types between the pyroxene and hornblende rocks may indicate that they are of different ages, and it is not unlikely that the formation of the dioryte followed shortly after that of the norytes and gabbros. Together these three types compose the long narrow belt of basic rocks that have broken through the ancient gneisses.

It is difficult to give with any degree of certainty the relative age of the granites since the requisite data for the determination of this are wanting. It seems probable, however, that they are younger than the norytes and diorytes. The presence of the numerous granite and pegmatyte dikes in the basic rocks may indicate that the granites of the main mass lying to the south are younger, though no connection between these dikes and the larger granite area was observed. The gradation of the granite into dioryte and the absence of any line of separation between them is thought to be evidence that their difference of age is not very great.

The peridotytes and pyroxenytes were erupted at a later period than the norytes and gabbros through which they have broken. Some of the pyroxenytes, however, apparently form peripheral facies of the noryte and probably belong to the same age as the latter. The pegmatytes are more recent than the basic rocks and serpentines and since the latter have originated from non-feldspathic types the acid dikes are also younger than most of the peridotyte and pyroxenyte. The last rock to be erupted was probably the diabase composing the dike which cuts the noryte-gabbro mass, and was formed in late Triassic or early Jurassic time.

The northeastern Maryland area taken as a whole seems to furnish an example of the occurrence of several rock types which represent the facies of a single magma and unite to form a geological unit. This view does not necessitate the supposition that all the rocks were formed either at the same time or by a continuous eruption, but there may have been several periods of activity during which different types were produced, and as already stated, this was doubtless the case in this district.

PLATE XVI.

Fig. 1.—Dioryte.

From one mile northeast of Rising Sun. Section No. 71. Magnified 20 diameters. Ordinary light. The hornblende occurs mostly in lath-shaped individuals which form clusters scattered through the feldspar. Considerable magnetite is also present.

Fig. 2.—Quartz-Mica-Hornblende-Dioryte (tonalyte).

From one-half mile west of Porter Bridge. Section No. 260. Magnified 20 diameters. Ordinary light. A good sized biotite individual shows near the center of the field and hornblende is seen near the edge. The feldspar is largely altered to epidote, which forms irregular crystal aggregates. The clear white mineral is quartz.

PLATE XVII.

Fig. 1.—Noryte.

From one mile west of Oak Grove schoolhouse. Section No. 237. Magnified 20 diameters. Ordinary light. The white feldspar is not as cloudy as in many sections. The light colored mineral is hypersthene and the black is magnetite.

Fig. 2.—Noryte poor in feldspar.

From cross-roads three-quarters of a mile south of Rock Springs. Section No. 104. Magnified 20 diameters. Ordinary light.

This rock is composed largely of hypersthene with only a little feldspar. It is a common type and is intermediate between the noryte and pyroxenyte.

PLATE XVIII.

Fig. 1.—Peridotyte (wehrlyte).

From near the point where the west branch of Stone run crosses the state line. Section No. 43. Magnified 20 diameters. Ordinary light. The olivine is partially altered to serpentine. The diallage exhibits its characteristic columnar structure and its black inclusions. The olivine is confined chiefly to certain bonds or layers, one of which shows on the side of the figure. This mineral also occurs included in the diallage.

Fig. 2.—Pyroxenyte (hypersthenyte).

From Oakwood. Section No. 159. Magnified 20 diameters. Nicols partially crossed (made 55° angle with crossed position).

This rock is composed entirely of hypersthene. Eight or ten different individuals are shown in the figure.

PLATE XIX.

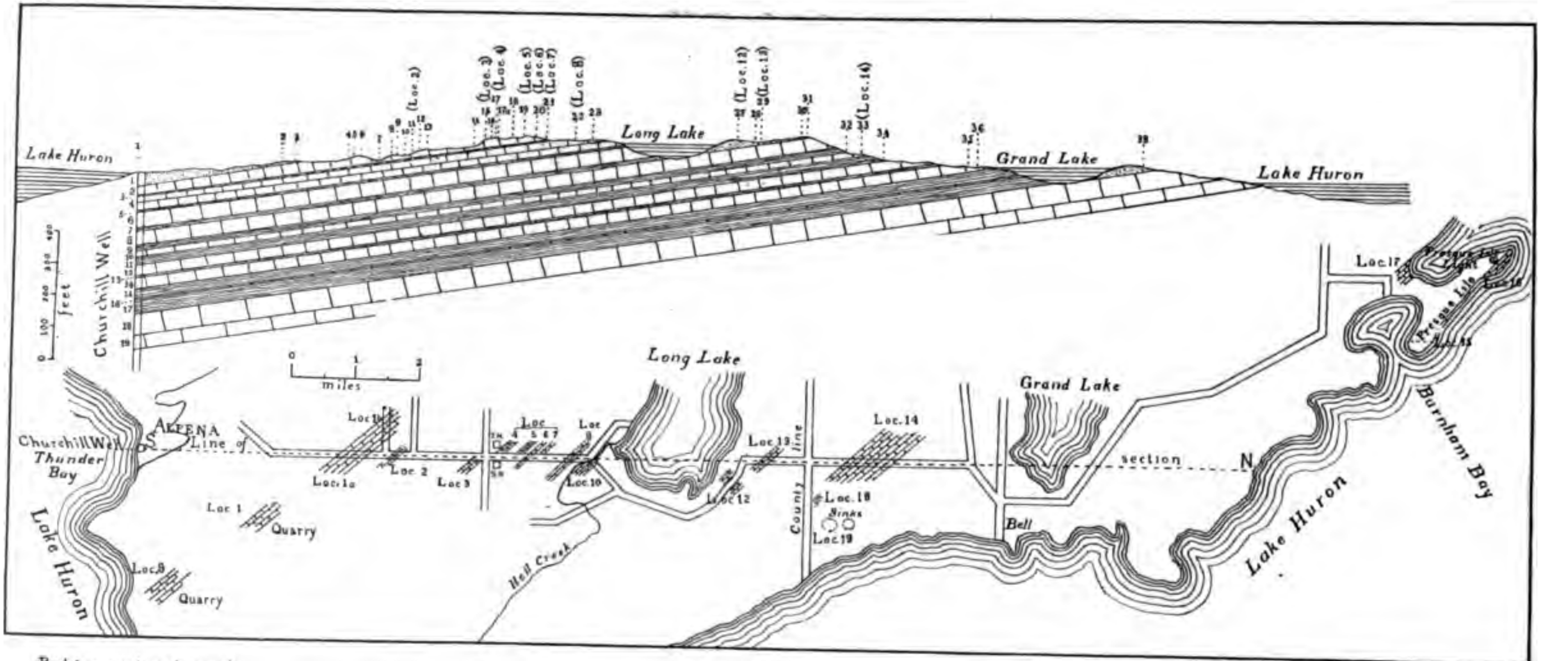
Fig. 1.—Saussurite gabbro.

From Octoraro creek just below the state line. Section No. 120. Magnified 30 diameters. Ordinary light.

This rock is a typical saussurite gabbro composed of fibrous, green, secondary hornblende (smaragdite), and white, opaque saussurite. The latter is made up almost entirely of zoisite. One good sized columnar crystal of this mineral is shown, bordered on either side by smaller individuals of the same.

Fig. 2.—Quartz-dioryte with epidotized feldspar.

From one-quarter of a mile below Porter Bridge on Octoraro creek. Section No. 266. Magnified 30 diameters. Ordinary light. The feldspar is replaced by aggregates composed of minute crystals of epidote. The dark, granular patches which appear scattered through the clear white quartz, and which mark the outlines of the feldspar crystals, are epidote. Several hornblende individuals show on the edge of the field.



Bed 1 - sand and gravel.
Bed 3 - thin shale bed.
Bed 5 - " " "
Bed 13 - " " "
Bed 16 - thin limestone bed.

GEOLOGICAL SECTION AT THUNDER BAY, MICHIGAN.

A PRELIMINARY GEOLOGIC SECTION IN ALPENA AND PRESQUE ISLE COUNTIES, MICHIGAN.*

By AMADEUS W. GRABAU, Troy, N. Y.

PLATE XX.

INTRODUCTION.

The following section was prepared in the late summer of 1900, with the assistance of Mr. W. F. Cooper, of the Michigan geological survey. As no topographical map was available, the profile of the country along the section had to be prepared in the field, at the time the geological data were collected. Distances were measured by means of a cyclometer attached to the bicycle, which was the only conveyance employed in the field. To eliminate errors due to unevenness of the country and to other causes, the cyclometer readings were checked by special readings on the section lines. Elevations were obtained by reading the aneroid barometer at all the stations, as often as these stations were passed, and correcting these readings by the barograph record obtained from a stationary instrument at Alpena. Owing to the length of the section, the barograph corrections did not always prove satisfactory, especially as several severe atmospheric disturbances affected the aneroid in the northern part of the section, which were felt to a less degree at Alpena, where their record was obtained by the barograph.

LOCATION AND EXTENT OF THE SECTION.

The section is located in Alpena and Presque Isle counties, Michigan. It runs north from the city of Alpena along the meridian of 83° 27′ longitude west of Greenwich, and forms the western boundary of the eastern third of range 8 E. It extends through the whole of townships 32 and 33 north and parts of townships 31 and 34 north. The total length of the section is nearly eighteen miles, but the distance covered in its preparation was nearly double that.

The section is interrupted near the middle by Long lake, and it passes by the eastern end of Grand lake. It strikes the shore of lake Huron about four miles southeast of Presque Isle

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light. About one-half of the line of the section is along a north-south road.

TOPOGRAPHY OF THE SECTION.

In the following table the distances between stations as calculated from the cyclometer readings are given. The elevations given are calculated from the aneroid readings and corrected by the barograph readings. The resulting elevations are of the various stations above the mean level of lake Huron, which is taken as 580 feet above the sea.

STATION, NUMBER AND LOCATION.	Distance between points. mi. — yds.	Elevation above Lake Huron. (580 ft. A. T.)
1. Thunder Bay	....	00.0
2. Round House	2.2 — 66	27.7
3. Sec. 15, N. E. Cor	.2 —110	40.7
4. Sec. 10, E. line base of terrace	.8 — 66	44.4
5. Sec. top of terrace	.0 —110	56.4
6. Sec. 10, N. E. Cor	.1 — 22	59.4
7. Sec. 3, E. line, base of terrace	.2 —110	52.1
8. Section top of terrace	.1 — 88	62.1
9. Sec. 3, end road running west	.1 —	67.1
9a. Offset on same, top of terrace	.1 —	79.1
10. Sec. 3, E. line, base of terrace	.1 — 66	62.5
11. Section top of terrace	.1 —	72.8
12. Sec. 3, E. line top terrace	.6 — 88	85.8
13. Sec. 3, N. E. corner, road running west	.19—132	92.8
14. Sec. 34, E. line	.7 — 44	93.5
15. Sec. 35, W. line	.1 —132	103.5
16. Sec. 34, N. E. corner	.0 —154	119.9
17. Sec. 27, E. line top of terrace	.0 — 88	128.9
17a. Sec. 27, outcrop	.0 — 88	128.9
18. Sec. 27, E. line, base of terrace	.1 —154	120.2
19. Section, outcrop	.1 —110	124.2
20. Sec. 26, W. line	.1 —132	134.2
21. Sec. 27, E. line, base of terrace	.2 — 44	124.2
22. Section outcrops	.4 —132	119.2
23. Sec. 22, fork roads	.2 — 88	125.2
24. Sec. 22, centre north line	.7 — 88	117.9
25. Long lake	.8 —110	110.6
24a. Hell creek bridge	.2 — 22	100.6
25a. Sec. 23, north line, center	.5 —132	106.4
26. Road east of Long lake	1.2 —154	121.4
27. Sec. 3, E. line	1.1 — 66	125.2
28. Sec. 3, end road running west	.4 — 00	113.0
29. Sec. 3, E. line	.0 — 88	126.0

STATION, NUMBER AND LOCATION.	Distance between points. mi. — yds.	Elevation above Lake Huron, (580 ft. A. T.)
30. Sec. 3, E. line, top of ridge	.6 — 44	136.8
31. Town and county line	.0 — 88	136.8
32. Sec. 34, E. line, top of maraine	.6 — 00	134.8
33. Sec. 35, W. line, Rabiteau's farm	.2 —110	112.6
34. Sec. 27, E. line, base of terrace	.3 — 00	81.6
35. Sec. 22, E. line running west	1.3 — 22	63.4
36. Fork of roads	.1 — 88	76.4
37. Lake Huron at Bell	.1 —132	32.4
38. Grand lake at Lumber mill, Sec. 15, N. E. corner	1.4 —154	56.2
39. Top moraine, Grand lake	3.8 — 00	41.7
40. Grand lake isthmus	.2 — 44	11.7
41. Top gravel ridge, Club house	.1 —132	25.1
42. Kaufman's	.2 — 88	31.1
43. Lake Huron at Presque Isle Light	5.22— 00	33.6

Of the stations here recorded, Nos. 1 to 23, and Nos. 27 to 35, are on the section line; the others are either to the east or the west of the section line. From these data, the accompanying profile of the section (plate XX) has been constructed.

From a careful plotting, it appears that Long lake and Grand lake lie along the outcrops of shale beds of considerable thickness. The valleys of these two lakes, therefore, which extend along the strike of the strata, represent longitudinal lowlands, carved by streams of the subsequent type out of the softer strata.

STRATIGRAPHY OF THE SECTION.

Owing to the extensive drift coverings of this region, rock exposures are comparatively rare, and are confined to roadside cuttings, quarries and the few natural exposures, which are found along the tops of the terraces. From well-records, however, we gain a knowledge of the succession of beds, and of the thickness of the various members. Taking this as the foundation of the stratigraphic work for this region, we may attempt a correlation of those beds which crop out on the surface, with those recorded in the well. Lithic characteristics will have to be relied upon in such a correlation, and for the

area covered by this section, these may be considered reliable. This is especially the case, since all the strata entering into the section are off-shore deposits, with a minimum of coarse detritus, and hence of a character which remains uniform over a large area.

The following succession of strata in this region has been derived from the records of the Churchill well, the location of which is near the southern end of the section in Alpena.

The mouth of the well is near the level of lake Huron, and above the coral limestone of Alpena. This rock is the middle member of the Traverse (Hamilton) group of Michigan, and hence the entire upper portion of this group is unrepresented in the well record. At a depth of over 1250 feet, the well ends in the salt beds of the Salina group, having penetrated the entire lower Devonic rocks of the region.

SUCCESSION OF STRATA IN THE CHURCHILL WELL AT ALPENA, MICH.

		FEET
1.	Sand and boulders	41.0
2.	Hard white (light colored) limestone	25.0
3.	Shale	9.0
4.	Very hard white limestone	49.5
5.	Shale	2.5
6.	Extra hard gray limestone	40.0
7.	Blue shale	20.0
8.	Hard white limestone	34.0
9.	Shale, 7 feet white and slimy, possibly gypsum (?)	18.0
10.	Hard white limestone	23.0
11.	Very sticky blue shale	27.0
12.	Hard white limestone	32.0
13.	Shale	3.0
14.	Hard white limestone, upper ⅔ extra hard	39.0
15.	Shale	24.0
16.	Hard white limestone	5.0
17.	Shale, mostly blue	52.0
18.	Hard white and gray limestone, mostly extra hard	63.0
19.	Extremely hard (flinty) limestone	39.0
20.	Shale	25.0
21.	Hard gray and white limestone	103.0
22.	Shale	20.0
23.	Hard white limestone	86.0
24.	Sandy lime shale	10.0
25.	Hard white limestone	468.0

This carried the drill down into the rock salt of the Salina group.

Strata 15 to 17 are provisionally considered the equivalent of the New York Marcellus, though there is no evidence at present to indicate that the faunal characteristics, on which the separation of the Marcellus beds alone rests, are found in this region. For this reason it is perhaps better to speak of these beds as the lowest Traverse shales, regarding the five-foot stratum of limestone (No. 16) as an integral part of the series. The total thickness of this lowest shale series is therefore 81 feet.

Strata 18 and 19 are provisionally referred to the Dundee limestone, which is considered the equivalent (approximately) of the Onondaga limestone series of New York. The combined thickness of the two strata referred to this formation, is 102 feet.

Stratum 21 probably represents the Mackinaw limestone, a formation which is believed to be the time equivalent of the Manlius limestone of New York. It undoubtedly is of upper Siluric age, but the determination of its exact equivalency must be deferred until paleontological investigations are made.

Whether the shale of stratum 20 belongs to the overlying or underlying formation is likewise an unanswered question.

If the above correlations are correct, the well record gives us the following thicknesses of Devonic formations.

Traverse upper shales	not represented
Traverse middle limestone	25
Traverse lower shales and limestones	378
Total middle and lower Traverse	403
Dundee limestones	102
Total	505

The strike of the strata of this region is approximately northwest and southeast. The dip is 42 feet to the mile toward the southwest. This is equivalent to 30 feet to the mile along the line of the section.

A. Traverse Middle Limestone.

This limestone underlies a considerable area to the north and northeast of Alpena. It appears on the surface in the northeastern portion of the town where several quarries are opened in it (Loc. 1). It is also quarried in

the cement works quarry less than a mile east of the town, near the lake shore, or approximately southeast of the preceding locality. This is designated Loc. 9.

The rock first appears on the section line, about a mile north of the town (Sta. 4). It appears at intervals to the north of this, and is prominently exposed in the terrace which crosses the section line in a direct northeast line from the quarries. (Sta. 8).

This terrace continues northwestward and furnished another good exposure of the limestone about a tenth of a mile west of the section along the first west road. (Stat. 9a, Loc. 1b.)

Loc. 1. Quarries northeast of Alpena. The limestone is here almost wholly composed of corals and hydro-corallines, though brachiopods and other organisms are not wanting. The corals are Favosites and Acervularia, the former probably represented by a number of species. Large masses of the rock are entirely made up of these corals, which appear to be still in the place where they grew. Other large masses of the rock are composed of the hydro-coralline Stromatopora and allied genera, which also appear to be represented by several species. Among the smaller corals, species of Zaphrentis, Aulopora, and Ceratopora predominate, while the Bryozoa are chiefly represented by fenestelloids, and Lichenalia-like types. The chief brachiopods are: *Atrypa reticularis,* (an extremely convex form), *Spirifer* cf. *S. mucronatus,* Stropheodonta, several species, *Cyrtina umbonata* var *alpenensis, Gypidula romingeri* etc.

The central mass of limestone of this region has all the characteristics of an ancient coral reef in which the chief reef-builders were the Favosites Acervularias, and Stromatoporas. These formed the main mass of the reef, while between them grew the smaller species, and the other organisms which go to make up the *ensemble* of the reef population. A careful examination of sections in the quarries shows that there is an absence of stratification and regularity of structure in general, within the reef portion of this limestone. This is to be expected, since this portion of the mass is entirely of organic origin. In form, this portion is dome-like, and the stratified beds of limestone which flank it, dip away from it in all directions at an angle exceeding that of the normal dip of the strata of this region.

The origin of these limestone masses and the accompanying beds of stratified limestone may be explained as follows:

In the Devonic sea of this region, the luxuriant growth of corals and other lime-secreting organisms produced isolated reefs, which rose to within the sphere of wave activity. Being subject to the continued attack of the waves, these reefs were destroyed wherever the vitality of the polyps was insufficient to resist the wave attack. Wherever exposed, the dead coral rock was ground into a coral sand, this being accomplished in part by the direct activity of the waves, in part by the aid of tools chiefly in the form of loose blocks which were rolled about, and served to grind up the coral rock, and in part by the many reef-destroying organisms, which in every reef are actively breaking up the dead coral masses. The resulting coral sand was carried away by the waves and currents, and deposited on the flanks of the reefs, and in the quieter water beyond.

Stratification is well marked in such a fragmental limestone, or lime-sandstone, and it not infrequently happens that cross-bedding structure, ripplemarks, and other shallow water characteristics are shown in such a limestone. In fact, we may consider that there is no essential difference in structure between such lime-sandstones and ordinary quartz-sandstones, the mineralogical character of the component grains being the only distinction. In such a lime-sandstone fossils need not be abundant, in fact we could understand their total absence. Near the growing reef, which is the source of the coral sand, the minor reef organisms may be expected to occur, but their number would decrease in proportion as we pass away from the reef. In the immediate vicinity of the reef, an interlocking of the organically and the mechanically formed limestones occurs, for at times the coral sand encroaches upon the reef, and again the reef organisms extend outward, growing on the foundation of sedimentary coral sand. This inter-locking of the two types of limestone is well shown in the quarries opened in the reefs in question, and on either side the stratified limestone, consisting wholly of consolidated coral sand, is seen dipping away from the reef. This stratified limestone is strikingly barren of organic remains; only a few brachiopods or small corals being found at intervals. In texture it is very uniform, and in composition very pure, yielding upward of 97% of

$CaCO_3$. Some of the limestone of this type in Petoskey, Mich., and presumably of the same horizon, is reported to yield 100% $CaCO_3$. The purity of these limestones is readily accounted for when we remember that the reef-building organisms flourish only in water free from terrigenous matter. Since the stratified limestone beds which always accompany the reef are derived from the organically formed limestone, and since there is an absence of terrigenous matter within the area of their deposition, it follows that these limestones must be very pure, within a radius of some magnitude from the central coral reef, the source of supply of the lime sand. It furthermore follows that the thickness of the coral reef, and the thickness of the flanking fragmental limestones, may agree and that beds of great thickness may accumulate, depending on the length of time during which the reef remains in an actively growing condition.

It thus appears that the reefs are the most trustworthy guides to the purity of the limestones. Close to the reefs from which they were formed, these limestones will generally be free from foreign material, while this may increase in amount progressively with the distance from the reef.

Loc. 9. Quarry of Alpena Cement Co. This limestone is gray and crystalline, and heavy bedded showing for the most part perfect stratification. The coral reef character is shown in several parts of the quarry, its structure being very similar to the reef of the preceding locality. Large masses of Favosites and Acervularia make up the greater part of the reef, and with these occur large stromatoporoids. Among the associated remains are *Gypidula romingeri, Atrypa reticularis, Spirifer mucronatus, Pterinea flabella* and others.

This reef, though similar to the one of Loc. 1, appears to be entirely distinct from it. The two are, however, connected by sparingly fossiliferous coral sand, which was derived from both, and constitutes the main material of the bedded limestones.

Loc. 1a. The rock exposed here shows essentially the same characteristics as that of the preceding two localities. Favosites appears to be the most common fossil. Other fossils are *Atrypa reticularis, Spirifer granulosus, Zaphrentis* sp. and several species of *Stropheodonta.*

Loc. 1b. The limestone has here less the character of a reef, but appears to have accumulated in the immediate neighborhood of a reef. It is highly fossiliferous, Favosites and Stromatopora being very common, though apparently not forming very large masses as in the reef portions of the preceding localities. Stropheodonta is a well-represented genus, though the species are generally small. *Gypidula romingeri* and *Atrypa reticularis* are among the other common brachiopods.

It has not been ascertained what the actual thickness of the limestone is. In the Churchill well twenty-five feet are shown, but since these are overlain by drift, it is evident that this is merely the minimum thickness and that the actual thickness may be somewhat greater. That it is not very much more is indicated by the nearness of the outcrop of the overlying shales on the south.

Loc. 2. About two miles north of Alpena, at Sta. 11 on the section line, a highly fossiliferous limestone is exposed along the roadside and in the adjoining farm lands. This rock consists mainly of the stems and joints of crinoids, and of various Bryozoa, among which the fenestelloids are the most common. In the exposed portions the fossils appear to form a loosely agglomerate mass, without the interstitial filling of calcareous sand. Brachiopods are very common, and the space between the valves is generally unfilled, except for subsequently infiltrated calcite. The brachidium of these brachiopods is generally well preserved, indicating a freedom from disturbances. *Gypidula romingeri* and *Atrypa reticularis* are both abundant. Stropheodonta cf. *S. demissa* and *S. nacrea* are also common. *Chonetes coronatus* is a conspicuous species, while *Spirifer mucronatus* and *S. granulosus* are among the other characteristic brachipods.

Fenestella, Loculipora, and the other frondose Bryozoa are also well preserved, frequently still showing the original funnel-like form of the frond.

Crinoid stems and joints make up the greater portion of the mass. These are mostly enlarged, and changed to cleavable calcite. Dog-tooth spar is common in the cavities, which latter are very numerous, since all the remains are loosely joined, forming a porous or loose-textured rock.

No Favosites or other corals have been observed. The condition of preservation of these fossils is such as to point to

quiet and rather deep water wherein they accumulated, the depth being apparently beyond that of wave activity. This limestone is therefore of great purity, since it consists wholly of the calcareous remains of organisms. The position of the limestone appears to be near the base of the middle Traverse limestone (stratum 2), but its characters are probably not traceable over a very large area.

Loc. 3. About a mile north of this outcrop, at Sta. 15, is another outcrop of limestone along the west line of Sec. 35. Here the limestone has again the coral-reef character, with Acervularia and Favosites predominating. This exposure belongs near the base of the limestone series. Besides the fossils mentioned, Zaphrentis, fenestelloids, *Atrypa reticularis* and crinoid stems may be mentioned.

Loc. 4. This is two-tenths of a mile north of the last locality, at Sta. 17a, along the east line of Sec. 27. The limestone here is similar to the preceding, and belongs to the same series. It contains numerous crinoid remains, and Stropheodonta is the commonest genus of brachiopods.

B. The Lower Traverse Shales and Limestones.

Loc. 5. About a third of a mile further north, at Sta. 19, is an outcrop of impure but highly fossiliferous limestone, which weathers to a yellowish-brown color, and leaves an earthy residuum. The reef corals are rare, but other types, such as Zaphrentis, Aulopora, and the like, are met with. Brachiopods are common and among these a robust variety of *Atrypa reticularis* is the most abundant. Other common species are: *Spirifer mucronatus, Chonetes coronatus, Stropheodonta demissa, S. concava*, and *S. erratica* (?).

From the thin bedded character of this rock, it might well be mistaken for a shale in the drill record. At any rate, this rock underlies the crystalline limestone, and with the beds next below it probably forms the nine-foot stratum of "shale" (stratum No. 3) in the Churchill well record.

Loc. 6. Less than two-tenths of a mile to the north, at Sta. 20, is an outcrop of black shale, highly bituminous, and characterized by the extreme abundance of a small species of Stropheodonta. This is a species closely related to *S. plicata* of the Iowa Hamilton. The plications are angular near the beak, but become rounded and less pronounced toward the

front. The exterior of the shell is striate, the interior pustulose. When worn, the shell appears punctate. A few fenestelloids occur, but other fossils are very rare.

Loc. 7. This is at Sta. 21, something more than two-tenths of a mile north of the preceding locality. The rock is a dark-colored, somewhat shaly, fine-grained bituminous limestone, and lies just below the shales of Loc. 6. It is exposed at the base of a terrace, on the west side of the road, and fossils are very rare in the exposed portion.

Loc. 8. This is at Sta. 22, near the forks of the road south of Long lake. The rock is thin-bedded, gray, weathering to buff, and highly fossiliferous. Favosites and Acervularia occur, but not in very large masses. *Atrypa reticularis* is the most abundant brachiopod, being represented by an extremely convex variety. Several species of Stropheodonta occur, among which a variety of *S. demissa,* and *S. erratica,* and *S. inequistriata* should be mentioned. *Cyrtina umbonata alpenensis* also occurs. These limestones are probably a part of the stratum 4 series of the Churchill well.

Loc. 10. This exposure is at Sta. 24, where Hell creek, the outlet of Long lake, cascades over some limestone ledges. This locality is off the section, and the rock here exposed appears to be the correlative of the limestone series No. 6 of the Churchill well. Acervularia and Favosites occur here, and with these *Spirifer granulosus, Sp. mucronatus, Atrypa reticularis,* and Rhipidomella cf. *R. vanuxemi.* This same rock probably crops out close to the lake.

Locs. 11-13. These are small outcrops of limestone along the roadside at Stas. 26, 27 and 29 respectively. They appear to belong to the limestone bed (8) which underlies the blue shale of Long lake (7), and contain Acervularia, Gypidula, and other fossils characteristic of the massive limestones.

Loc. 14. This is at Sta. 33, half way between Long and Grand lakes. The best outcrops are along the roadside and on the farm of Mr. Rabiteau. The rock is thin-bedded and extremely fossiliferous, the fossils weathering out in relief. The limestone is not very pure, an earthy residuum remaining on the solution of the lime. This is by far the most fossiliferous series of beds in the region, the largest number of species in the collection having been obtained from the outcrops of this rock.

Brachiopods predominate, with the large and robust *Atrypa reticularis* at the head. *Gypidula romingeri* Hall and Clarke is also extremely abundant, while the Stropheodontas and Spirifers are common, and represented by all the common and some rare species. Chonetes, Productella, and other characteristic Hamiltonian brachiopods occur abundantly. Among corals the smaller types predominate, i e., Aulopora, Ceratopora etc. In the lower beds, however, the reef-building types occur, notably Acervularia. Stromatoporoids are also, though more rarely met with.

Loc. 15. This is along the shore of Burnham bay, southwest of Presque Isle. No outcrops are found here, but the beach is composed of rounded and subangular dark to light gray limestone pebbles. Chert is a common constituent of this rock, which probably belongs to the Dundee formation (representing the Corniferous limestone).

Loc. 16. This is in front of Presque Isle light, along the shore of lake Huron. A dark, somewhat shaly, apparently non-fossiliferous limestone crops out at the water's edge. This undoubtedly is the lower Dundee limestone (stratum 19) which probably forms the shore for a considerable portion of the county.

Loc. 17. This is on the mainland, north of Presque Isle. The rock, though locally disturbed, chiefly by shore ice, is undoubtedly in place, and represents the stratum overlying that which crops out in front of Presque Isle light. The rock is a very compact and uniform grained limestone, of a drab color, and sparingly fossiliferous. Almost the only fossil found in it was a large and rather smooth Paracyclas.

Loc. 18. This is on the farm land north of the county line and east of the line of the section. The outcrop is in line with those of Loc. 14, and of the same type, containing also the same species of fossils.

Loc. 19. This is at the sink holes north of the Presque Isle county line, and east of the line of the section. The rock exposed in the walls of these sinks is as follows:

	FEET
Fine grained limestone, of a very compact texture	12
Shale, bituminous at top, but becoming more calcareous downward, with fossils of the Hamilton types	—

The thickness of the shale has not been ascertained. The limestone underlies the shaly limestone of Loc. 14, and if the correlation of the latter with the "shale" of stratum 9 is correct, this limestone and underlying shale are to be correlated with strata 10 and 11 of the Churchill well, respectively.

Some of the sink-holes are 50 or more feet in depth, but their sides are difficult to examine, since they are usually perpendicular, or else covered by talus.

Shales with fossils of the Marcellus type are said to be exposed in the vicinity of Bell, but they have not been seen. A fragment, however, containing a characteristic Marcellus Chonetes, and obtained from this exposure, has been seen. The location is along the strike of the shales out of which Grand lake is carved.

Rensselaer Polytechnic Institute, May, 1901.

EDITORIAL COMMENT.

THE ARCHEAN OF THE ALPS.

The very able and interesting volume by Duparc and Mrazec, which has lately come to our notice, is a valuable contribution to the geology not only of the Alps, but of the Archean of every country so fortunate as to have any Archean rocks. The investigation was carried through seven years. It may, therefore, be presumed that the results reached are the best that can be attained by the intelligent use of all methods of modern geological research. Careful and extended fieldwork was supplemented by chemical and petrographical laboratory study.

The monograph abstracts the opinions of former geologists as to the nature and relations of the Mont Blanc massif, but carries the examination into greater detail than any predecessor, reaching, therefore, somewhat different conclusions. It is specially detailed and complete on the relations of the granite (called protogine, a term which the authors would discard) to the schists, and throughout all its descriptions it is illustrated by half-tone reproductions of photographs of Alpine scenes.

*Recherches géologiques et pétrographiques sur le massif du Mont-Blanc. Par Louis Duparc et Ludovic Mrazec. 24 plates. pp. 228, quarto, Geneva, 1898. (Mem. Soc. Phys. et Hist. Nat., Tome xxxiii, No. 1)

French and Italian geologists have differed on the question of the nature and origin of the rock of the massif of Mont Blanc, some regarding it as an integral part of the schists, but more gneissic, and some as an eruptive rock independent of the schists. The authors, however, share with Michel Lévy the opinion that it is an igneous rock intrusive into the schists, but they lay special stress on the metamorphism of the schists, developed by the granite, and the endomorphism of the granite produced by the schists.

The authors accept two rocks, viz: the granite and the schists, as independent, unallied facts. They trace out their lines of contact and map their separate areas. They make petrographical and chemical examinations of these two end terms, all tending to demonstrate and emphasize the contrasts that separate them in the field and in the laboratory. Then they gather together the points of alliance. They find there are four terms in the series instead of two terms and that from one extreme to the other there is a gradual passage, thus, (1) schist, (2) schistose granite, (3) gneissic granite, (4) granite. This gradual succession is found not only once, and twice, but in many instances. It is an important point in the genetic study of the igneous rocks to find this fact so well established by those able investigators, for it has been sometimes affirmed that there is no such transition between the schists and the granites, and can be none. Reference may be made to page 23 where the phenomena about the Mer de Glace and the Grande Becca are described. This result is identical with that recently reached in the investigation of the Archean crystalline rocks of Minnesota. This gradation from schist to granite, which reasonably interpreted in Minnesota as an indication of an original alliance of the two extremes, through the means, in one origin, is differently viewed by Messrs. Duparc and Mrazec, and the rocks at the extremes of the series are considered as separate in origin and in date. They detail at considerable length the structural relations of the granite with the schists (mica schists) finding it frequently eruptive into the schists.

Owing to the stratified condition of the protogine Favre considered it a granitoid gneiss older than the mica schists which envelop it. Lory like Favre ranked the protogine amongst the crystalline rocks but younger than the mica schists.

He reached the conclusion that the massif of Mt. Blanc forms a synclinal pinched between two faults, but later in consequence of an excursion with Michel Lévy he recognized the eruptive nature of this rock. The Italian geologists, with Zaccagna at the head, consider it also as a particular facies of primitive gneiss. Amongst them this opinion is strongly rooted, for in 1893, in his "Geology of the province of Turin," Baretti uniformly considers the protogine as a lower term of the crystalline rocks.. With Gerlach the protogine of Mt. Blanc is manifestly an eruptive rock. Its apparent stratification is a result of compression. Michel Lévy shares the opinion of Gerlach, as to the eruptive and intrusive nature of this rock. He chiefly bases his argument on the contacts of the rock with its crystalline mantle, and also upon the phenomena of injection and of metamorphism which it develops there. The authors themselves, in their earlier papers, have started from the same point of view and have insisted chiefly on the metamorphism in question. It can be stated, in general therefore, that, with the exception of the Italian geologists, there seems to be at present an approach to agreement on the eruptive nature of the protogine of Mt. Blanc.

But having agreed that it is an eruptive those who have studied this protogine seem not to have accounted for its origin, nor for the terms that intervene between the normal and completely developed granite and the schists into which it is so plainly intruded. What is the cause of Nos. (2) and (3), the schistose granite and the gneissic granite? The former has certain suggestive points of petrographic likeness to the mica schists. It runs imperceptibly into the gneissic granite. The gneissic granite (No. 3) cannot be separated, in the field, from the protogine (No. 4).

It will be instructive to gather together some of the evidences, given by the authors, that go to show that these four terms are but steps in one great event, phases that depend on incompleteness of the process, or on difference of original composition and structure in an original sedimentary rock.

The authors say (p. 20): (1) The granitic type of the protogine is light colored, with variable grain, often very fine, with black mica evenly disseminated, with great regularity, in the mass. The gneissic type is usually of a darker color, greenish,

and always more or less schistose. It separates more easily into layers than the foregoing. Plagioclase feldspars occur in both, in the latter in large white crystals. "All forms of passage between these two types are found." Thus, the enlargement of the feldspar crystals of the gneissic type transforms the rock into a true augen-gneiss the large feldspars of which with square sections sometimes measure five millimeters in length by two or three in width, and are alligned parallel. The color of the rock then becomes lighter, and the fragments that it contains more separated. Then the orientation of the feldspars disappears, the schistosity diminishes more and more, and the feldspathic element is dispoesd in all directions with respect to itself, and there is formed a rock still granitic, but of a type almost porphyroidal. At the same time the basic element marks out in the rock real lines or trains analogous to those of particles carried in suspension in a viscous liquid."

(2) These two types of granitic rock are not capriciously and irregularly distributed in the midst of the protogine. The true granitic type forms the southern slope of the massif, the col du Geant, the Grandes Jorasses, monuts Roux, the Dolent, the peaks of Planereuse, the Portelet, the summits of the Chatelet and of Breya, where, further, the grain of the rock becomes remarkably fine. But the gneissic varieties on the contrary are found in the neighborhood of contact of the protogine with the schists, and also in the central area of the massif where they appear to be arranged in lines along more or less definite axes, viz: between the Grandes Aiguilles and the summit of the Grandes Jorasses (p. 21). While the authors declare it is impossible to define the limits of the different parts of the gneiss, owing to the transitions to granite, as mentioned, they state that in general along certain axes the gneissic belts are manifest and separated one from the other by zones in which is evolved the granitic type. Further, intercalated in the midst of the gneiss are bands of real mica schist. In total, therefore, the mountain is composed of two great zones, more granitic than gneissic, enclosing between them a region where the protogine is more gneissic and schistose, a region which corresponds to a great central depression.

(3) The mica schists are accompanied by amphibolytes.

(4) While there are distinct apophyses of the protogine

that penetrate the schists in an intrusive manner (p. 22) there are other places where there is a gradual passage from the schists to the protogine (p. 23) through gneissic and more or less augen types. This occurs at the "angle" of the Mer de Glace, at Aiguille des Grandes Mantels, at the peak des Rachasses, in the summits that overlook the glacier d'Argentières and des Rognous. It is the same on the opposite side of the glacier d'Argentière and in the valley of the Durnand; also at the stairway from Six des Orques to la Gurra and in reascending under the summit of Grande Becca, and elsewhere. Here the protogine passes insensibly into gneissic varieties. In the same gorge of Durnand "are seen first schistose bands, which little by little become more gneissic and which pass evidently to protogine."

These field appearances are identical with those which the writer has described in the final report of the Minnesota geological survey and which, prior to careful petrographic examination, seemed to him conclusive to prove the cotemporaneity of origin of all rocks concerned, and also the origination of all the igneous characters of the granite and of the gneiss from intense metamorphism and even fusion of the elements of the mica schist. The gradual transitions occur, under this hypothesis, where the original strata were not completely fused and displaced or were of differing composition, and the abruptly intrusive contacts where the plastic or molten matter accompanied and aided by hot water, was carried amongst the still infused rocks of the original terrane of the region. Where this transference was more gradual, and was largely due to water solutions, the pegmatitic structures were formed.

There is an essential difference, as relates to the schists, between these hypotheses. According to the authors the schists, as schists, preceded the granite. According to the writer they are cotemporary with the granite, and represent the lower terms of the same process that gave origin to the granite.

(5) The silica of the protogine is found to vary from 66 to 76 per cent. which shows a granite relatively acid, distinguished by that fact from the granite which forms crystalline zones exterior to the massif of Mt. Blanc. These variations

in acidity in the protogine the authors believe cannot be due to a lack of homogeneity in the original magma, but are to be attributed to modifications, more or less local and partial, resulting from the action of the crystalline covering, *i. e.*, the schists, upon the rock "de profondeur." Going beyond the massive nucleus, the authors find that the surrounding schists having 59.30 per cent of silica, are still less acid than the surrounding gneissic rock. In other words, that which is the most acid rock of the series is that which presents the strongest igneous characters, and which has most frequently and effectively penetrated the less acid in the form of bosses and dikes. The degree of acidity varies pari passu with the degree of fluidity of the rock considered. Such difference in acidity has frequently been appealed to to prove the genetic difference of the schists from the granite. There is no more obvious or common remark than that a crystalline rock, such as a granite, resulting perhaps from a fusion of fragmental materials, ought to contain substantially the same degree of acidity as the aggregate of the materials from which it was derived. There is nothing more evident. But it cannot be inferred from this that the granite at a definite point of intrusion should show the same degree of acidity as the schists which it intrudes, for the very fact of the intrusion implies that the granite has been moved from the point at which it may have originated, and hence that it may have started with a greater amount of acidity. If the action of quartz under metamorphism be considered a moment it will be found as a general law that the more acid rock material fuses sooner than the less acid. Quartz is the most mobile under metamorphism of all the rock-forming minerals. It is both first and last to show the effect of metamorphism. If such metamorphism be continued till it results in plasticity or fusion, it is an inevitable consequence that the most acid material would first become plastic. Hence, in all cases, when not disturbed by abnormal or accidental conditions, acid intrusives are found penetrating the less acid schists. Acid nuclei, in granitic mountain districts, are surrounded by less acid rocks, and inclusions of the less fusible schists are found in the granitic mass. In all cases, whenever a single epoch of metamorphism is considered, the more acid intrudes the less acid. In the rare case of dikes more basic than the

enclosing rocks, they are to be attributed perhaps to later disturbances, at least to disturbances that penetrated to deeper levels and involved rocks that are genetically isolated from the rocks which they cut.

(6) The authors enter largely upon the examination of the fragmentary inclusions of the schists in the protogine, and then upon a description of those extended ridges of gneissic schist which maintain their form and direction over remarkable spaces, although embraced in the usual facies of the protogine. As to the former the authors reach the conclusion that they are masses detached from the original schistose terrane and do not result from basic segregations from the magma of the protogine. With this conclusion there can be little, if any difference of opinion. In regard to the latter, they find that these bands exhibit evident insensible transitions to the protogine, and are very frequent. "These schistose intercalations are much more frequent than has been supposed hitherto, and it would be an error to designate the massif of Mt. Blanc a compact nucleus of protogine" (p. 61). As they are less resistant than the protogine they are easily eroded, and give rise to cols and depressions. The authors have discerned the importance of the relations of these extended bands to the protogine, in the formation of any theory of the genesis of the massif of Mt. Blanc itself. In the col du Geant these schistose alternations appear with intervening protogine of differing types (p. 65). They reach the conclusion that they are local intercalations of the schist in the protogine, or true synclinals of the overlying schistose mantle, isolated and enveloped in the protogine, but apparently sometimes of a rock somewhat later than the schists: but a greater portion of the inclusions are analogous to the crystalline schists that flank the protogine. They cannot, in any case, be attributed to a dynamic crushing of the protogine.

To the writer these great bands of less granitic rock, sometimes approaching veritable schist, appear to be remnants of the original fragmental terrane, exhibiting all the transitions to protogine, and the same modification in lithology, that are exhibited by the mica schists. They are central instead of marginal, with respect to the protogine, a fact which may be attributed to infolding or to some great irregularity in the dis-

tribution of the force that gave origin to the general metamorphism.

The southeastern flanks of the Mont Blanc massif differ from the western. Here is found a great mass of acid schists, characterized by satiny lustre, and by porphyritic quartz. From the description given this group is plainly quite like certain Archean light colored sericitic schists which have been described in several places in Canada, and in northern Minnesota. They vary from exceedingly fragile to firm and dense rocks. They are often distinctly bedded by sedimentary action, and they also form large bands and bosses that rise into ridges or hills of considerable size and endurance. They frequently become strewn with quartz crystals and by ortho-clase. They then resemble quartz porphyry, and have sometimes received that name.* They pass, however, to a more green porphyritic rock, more basic, but still a part of the schist series, and also become a fine mica-schist more or less felsitic. In general this series is described by the authors under the term "porphyres quartzifères," but they distinctly take note of the intercalations of schistose rock and of granulyte (p. 89).

These schists and porphyries are allied to the schistose rocks of the Mont Blanc region rather than to the granite, and between them and the granite there is no known gradual passage. Yet the authors describe them from the view point of eruptive origin, and their schistose features they ascribe to dynamo-metamorphic crushing. They never contain vitreous matter, but quartz is developed as spongy grains embracing the other elements, as vermicular quartz and as micropegmatyte by entering into the feldspars. Of this secondary quartz there is a copious development. According to the authors these rocks under dynamic action take on such characters that they cannot be distinguished from certain horn schists, since the mica is drawn out and disposed in parallel trains, the quartzes are broken and the parts lie adjacent. In other cases the feldspars are similarly broken, and the rock has the aspect of a sericitic schist.

The chemical similarity of these rocks with the granitic veins, which cut the granite, suggests to the authors (p 109) that they are from the same magma, but consolidated in two

*A notable instance of this is discussed by the writer in Vol. IV of the final report of the Minnesota Geological Survey, pp. 525-589.

different manners—a suggestion, however, which seems to have little validity since (p. 87) they form the cement of a conglomerate constituted of blocks and pebbles more or less rounded of granulyte and of protogine. There may, however, be some error of observation in correlating this conglomerate with the porphyry in general, since (p. 110) the contact of the porphyries with the protogine is said to be fresh and distinct, but often accompanied by intervening laminated or micaceous rock, and by the alteration of the protogine to aplyte and the occurrence of great numbers of veins of granulyte, in the protogine—features that seem to indicate the later date of the protogine. How it could be done the authors do not indicate, but they assume that the porphyries (here included this great series of sericitic rocks with their variations) have been subjected, locally, generallv and wholly, throughout their mass to dynamic forces more or less violent, which, when intensified, were able to destroy and grind up entirely the minerals of the first consolidation and to transform the rocks into true schists with a sericitic detrital aspect. Only calling to mind the authors' rejection of such a process in the case of the crystalline schists of the western part of Mont Blanc, for the origination of those schists from the crushing of the protogine, it is well to state here that according to studies carried out on similar rocks in northern Minnesota, these rocks are of oceanic origin, largely detrital, varying to graywackes, and that they originated cotemporaneously with others that are now mica schists, and that probably when they are consecutively traced from the southeastern flanks of Mt. Blanc they will be found to be inseparable from the mica schists which are penetrated by the granite of Mt. Blanc, as in the Val Ferret (p. 131), and that in general they escaped the profound metamorphism of the Alpine Archean by reason of their geographic location with respect to the center of greatest dynamic activity.

As has been stated, the authors everywhere recognize the fact that the mica schists, the gneiss and the protogine (or granite) are linked by insensible gradations in areal relations and in petrographic and chemical association into one continuous petrologic series, the granite and the schist being the extremes. Not only are there such interlocking gradations, but there are similar major features that help to form the com-

mon chain. For instance (p. 117), there are isolated lentilles of pegmatyte in the schists, these being from one to twelve centimeters in diameter, and similar lentilles are developed in the gneiss, and these are sometimes generated at considerable distances from any known granitic mass.

All these minute, as well as the grander alterations in the schists of Mont Blanc, the authors ascribe to two agents which acted in conjunction, viz: dynamometamorphism and magmatic injection. The work is, in its general conclusions, an able contribution to the idea of endomorphism of intrusive rocks by the reaction of the intruded rock on the intrusive. Frequently the authors find a bordering band of gneiss or gneissic schist round about the central massif. This rock is sometimes classed as a more perfect metamorphic and sometimes as a gneissic part of the granite (p. 158). In either case the explanation is the same, and in all cases in which granitic aspects appear in the schists they are supposed to be due to the granitizing effect of granitic injection in the near vicinity. In other words the interchange of rock material was mutual and in opposite directions. The acid element entered the more basic schists, and the schists gave of their iron and magnesia to the granite. This process is reasonable, and in some degree certain, given the conditions precedent, but it assumes that the crystallization of the schists had been produced anterior to the appearance of the granite, instead of being the accompaniment of it. It is based also on an initial presumption which is not taken into consideration, but which is more fundamental. The chemical difference between the crystalline schists and the granite, from which the authors derive their conclusion of the different origins of these two rocks, is local and insufficient for their inference. It is probable that the schists, considered *en bloc*, including the sericitic schists and all the rocks associated with them, would give, in case of complete fusion, a magmatic rock identical or similar to the granite of Mont Blanc.

It seems to the writer, therefore, that there are lacking certain links in the argument for foreign origin of the granite. On the contrary the granite seems to have an autogenetic origin, because:

1. The widespread metamorphism cannot be attributed to contact effect. It is more of the nature of regional metamor-

phism. The immediate contact zone of the schists is not different from the schists at some meters distant from the granite.

2. It is hardly in accordance with known contact metamorphism, nor with any observed nor hypothetical case, that an intrusive rock should impart to the intruded rock siliceous elements that should arrange themselves in banded order, such as seen in the gneisses and gneissic schists extending for such distances in successive alternation.

3. It is impossible to believe that a granitic intrusion should cause the formation by infiltration of siliceous elements, of a banded gneiss or of granite within the schists at a distance say of a quarter of a mile from the known intrusive rock.

4. There is an easier and more natural explanation of the origin of the gneisses and schists, by supposing them to have existed as sedimentary strata of varying acidity, subjected to profound regional metamorphism, in the application of which were concerned both dynamometamorphism carried to actual plasticity of the fragmental materials, "magmatic" intrusion of some of the fused materials amongst the parts not plastic, and pneumatolitic transference of much acid matter amongst the same, forming pegmatytes and veins. This slow process was the cause of the total recrystallization of the fragmental materials *in situ*, so far as the same were not extruded as lavas, thus accounting for the absence of vitreous matter. This method of origin does not require the extraction of so much silica from the magmatic granite and its dissemination amongst the schists as to leave it a basic rock, nor the loss of so much basic material by the schists as to render them acid: it only requires that the elements pre-existing in the fragmental strata shall be heated, pressed and re-crystallized *in situ* in the presence of moisture or rendered plastic. The granite and the schists and gneiss then would date from the same epoch, and be derived from the same elements, differing in kind because of the variability of the dynamic force in its geographic application, and because of the variability of the original stratified mass.

5. All the ascertained facts, whether structural, chemical, petrographic or petrologic, would find consistent causes, without resort to hypothetical or doubtful processes.

The phenomena that have been studied by the authors are parts of a larger problem than that they have applied themselves

to. Their demonstration of the grading of the schists into igneous rocks of various kinds is very important, and such gradation can hardly further be questioned by geologists. Whether such igneous rocks (granite, gneiss, dioryte, syenyte) originated *in situ* from pre-existing rocks, mostly detrital, or are derived *de profondeur*, entirely strangers to the rocks that they are now in contact with, is a problem that remains to be solved for the Archean of the Alps. N. H. W.

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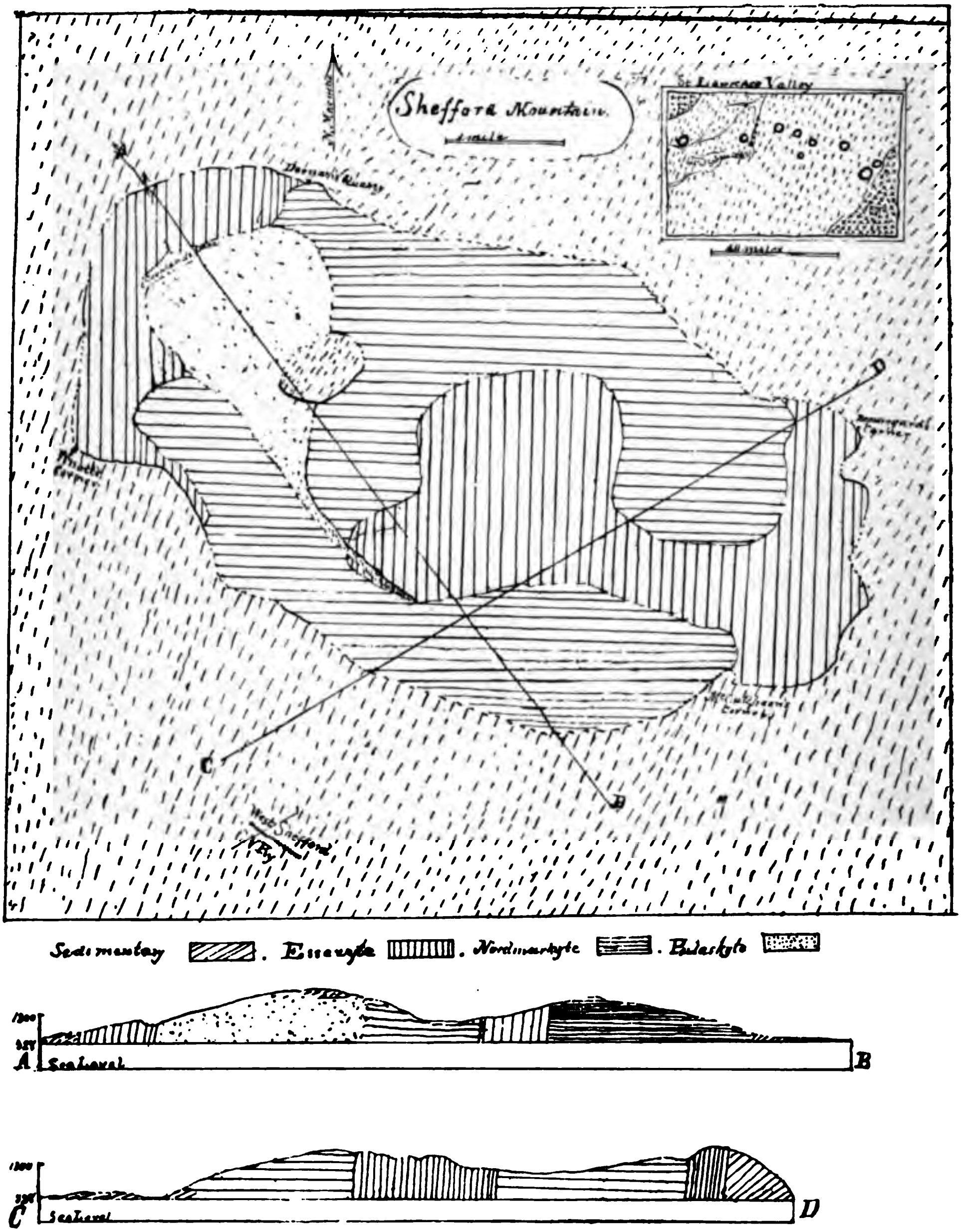
Shefford Mountain
1 mile
N. Magnetic
St. Lawrence Valley
40 miles
West Shefford
A
B
C
D
Sedimentary
Essexyte
Nordmarkyte
Pulaskyte
1300
Sea Level
A
B
1300
Sea Level
C
D

THE
AMERICAN GEOLOGIST.

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ON THE PETROGRAPHY OF SHEFFORD MOUNTAIN.*

By JOHN A. DRESSER, Richmond, Quebec, with Chemical Analyses by M. FRANK CONNOR, Ottawa, Ontario.

PLATE XXI.

EXPLANATION OF PLATE.—The mountains indicated on the small map as crossing the St. Lawrence valley are the following in order from left to right: Mount Calvaire, Mount Royal, Montarville, Beloeil, Johnson (which is almost due south from Beloeil), Rangemont, Yomaska, Brome and Shefford. Rigand Mountain, which is beyond the western limit of this map, was considered by Logan also to belong to the series, but the recent researches of Mr. O. E. LeRoy (Bull. Geol. Soc. Am. 1900,) render the accuracy of this view extremely doubtful.

The broad flat valley of the St. Lawrence river, which separates the Laurentian highlands on the northwest from the hilly region of the Appalachian uplift at the southeast, is crossed in the latitude of Montreal by a line of volcanic hills, which appear at intervals of ten to twenty miles and rise to hights varying from seven hundred to twelve hundred feet above the surrounding country. Their igneous origin and intrusive relations have long been known,† the best known being Mount Royal, which gives its name to the city of Montreal at its foot.

The most easterly member of this series (see map) is the elevation known as the Shefford mountain, which covers an area of rather less than nine square miles in the county of Shefford about fifty miles east of the city of Montreal, and

*Published with the permission of the Director of the Geological Survey of Canada.

†SIR W. E. LOGAN and DR. T. STERRY HUNT, *Geology of Canada*, 1863, p. 655, and also in earlier reports.
DR. R. W. ELLS. Annual Report, Geological Survey of Canada, 1894, part 3; DR. F. D. ADAMS, Remarks, p. 74, ibid.
Canadian "Record of Science," Vol. VIII, No. 2.
A monograph on Mount Johnson, of this series, which will soon appear from the able pen of Dr. Adams, will be looked for with much interest by petrographers.

rises nearly twelve hundred feet above the surrounding country or about sixteen hundred feet above mean sea level.

With the larger and adjacent mass of Brome mountain, which work in progress shows to belong to the same series, Shefford mountain lies well within the folded belt of the Appalachians, though owing to the extensive denudation from which the region has suffered, this fact has little if any discernible influence on the topography of the immediate locality. The sedimentary strata which surround the mountain have been shown to be of Sillery (Lower Cambrian) and Lower Trenton age. They are found to wrap around the igneous mass of the mountain mantling it with a hardened contact zone to a hight of three hundred to one thousand feet above the surrounding country, according to the direction of glaciation. Above the latter hight the mountain rises upwards of two hundred feet, the summit being capped by an outlier of Trenton slate about a quarter of a square mile in extent. This preserves the cleavage, dip and strike of the similar rock at either side of the mountain, and is penetrated by dykes from the underlying igneous rocks.

From these facts together with the absence of tuffaceous material, and the general arching of the strata around the mountain, it is inferred that Shefford mountain is an uncovered laccolith rather than the denuded neck of a once active volcano. It is also evident that the depth attained by erosion in this part of the St. Lawrence valley cannot have been less than twelve hundred feet, and may have been much more. Its maximum does not seem to admit of any very reliable means of computation. The restoration of the folds of the strata, which are altogether worn down, would be the natural method of investigation, but the strike of cleavage, coinciding with that of the bedding, while the dip of the two is probably very different, so far complicates the question as to seemingly preclude the possibility of any but the most hypothetical calculations.

In the igneous mass three classes of rocks whose field relations show them to be products of as many separate periods of irruption (map) are easily distinguished. They are in order of intrusion, essexyte, nordmarkyte, and pulaskyte. Their comparative mineralogical composition may be shown as follows:

	Essexyte	Nordmarkyte	Pulaskyte
Constituents			
Essential	Plagioclase	Microperthite	Orthoclase
	Orthoclase		Plagioclase
	Hornblende	Augite	Hornblende
	Augite	Hornblende	Augite
	Biotite	Biotite	Biotite
Accessory	Apatite	Magnetite	Magnetite
	Magnetite	Sphene	Sphene
	Sphene	Apatite	Apatite
	Sodalite	Nepheline	Sodalite
	Nepheline	Sodalite	Nepheline(?)
Structure	Hypidiomorphic	Hypidiomorphic	Porphyritic Trachytic

Essexyte. This is a rather coarsely crystalline rock of a dark gray color and weathering to a rusty brown. On a fresh fracture feldspar is seen to be slightly the most abundant constituent, and by the aid of the lens part of it can be seen to be striated and hence triclinic. A black or dark brown hornblende is the most conspicuous of the dark colored constituents. This varies considerably in amount and in some of the contact phases makes up fully half the rock, but in general it is quite subordinate in proportion to the feldspar. In parts of the rock considered typical it is also exceeded in quantity by a light colored augite, and brown mica is quite abundant.

A mechanical separation of the rock was made by Mr. O. E. LeRoy at the petrographical laboratory of McGill University which gave the following results regarding the feldspars—when the specific gravity of the Thoulet solution, which was employed, was reduced from 2.689 to 2.651 much feldspar fell; between 2.651 and 2.562 much also fell, part turbid and part clear grains; between 2.583 and 2.524 a smaller amount, all turbid. There were no lighter constituents.

Grains from each of these specimens were mounted and ground for microscopic examination. The first was found to be rather broadly striated and to have an extinction angle as high as 36° measured on the albite twinning lamellæ. These are accordingly classed as labradorite. The second, in which the twinning lamellæ are finer, showed only very low angles of extinction in the clear grains, which are referred to oligoclase-andesine. The turbid grains of this weight are found to be either zeolitized labradorite or composite grains of ortho-

clase and a heavier constituent. The lightest constituent was found to be unstriated feldspar presumably all orthoclase. It fell in smaller amount than either of the others.

In the thin section of the rock the labradorite is found in better formed crystals, but in smaller amount than the oligoclase-andesine, while orthoclase, which can often be distinguished by its incipient alteration, is the least abundant of the three feldspars.

Augite is colorless and without pleochroism. It shows characteristic cleavage, nearly right angled, and extinction angles as high as 45°.

Hornblende is brown varying in shade from deep chestnut to yellowish. It is trichroïc, the scheme of absorption being $\mathfrak{c} > \mathfrak{b} > \mathfrak{a}$. The greatest angle of extinction that was observed $c \wedge \mathfrak{c}$ was 27°.

Biotite in some instances is intergrown with horneblende, and in others encloses numbers of augite crystals promiscuously arranged, thus giving an excellent micro-poikilitic structure.

The structure of the rock is hypidiomorphic and the order of crystallization, the normal one for plutonic rocks. The ferromagnesian minerals enclose the basic accessories and are themselves generally of an earlier order of crystallization than the feldspars. Of the latter the labradorite has crystallized earlier than the oligoclase-andesine and both are cemented together by orthoclase.

The rock thus agrees essentially with the characters of the essexyte group, a near analogue probably being the augite dioryte of Rosita Hills, Colorado,* described by Cross (XVII, An. Rep. U. S. G. S). A specimen of essexyte from Salem Neck, Massachusetts, kindly given me by Mr. J. H. Sears of the Salem Academy of Sciences, agrees completely with some of the darker and more hornblendic portions of the Shefford mass.

The following are the results of (I) analysis of a specimen from Morriseau's quarry, Shefford, which, judging from the microscopic evidence, is probably the most acidic part of the intrusion;† (II) Augite-dioryte, Rosita Hills, Colorado; (III) Essexyte, Rangstock, Bohemia

*This has been included by Prof. Rosenbusch in the essexyte group.—"Elemente Gesteinslehre."

†A few small grains of quartz were found in a section from this specimen, the only quartz that has been found in this rock.

(cited by Rosenbusch, loc. cit.); (IV) The original Essexyte, Salem Neck, Mass.

	I	II	III	IV
SiO_2	53.15	50.47	50.50	47.94
TiO_2	1.52	.51	1.91	.20
Al_2O_3	17.64	18.73	17.64	17.44
Fe_2O_3	3.10	4.19	5.41	6.84
FeO	4.65	4.92	4.02	6.51
MnO	.46	.11		
CaO	5.66	8.82	7.91	7.47
BaO	.13			
MgO	2.94	3.48	3.33	2.02
K_2O	3.10	3.56	3.02	2.79
Na_2O	5.00	4.62	5.52	5.63
P_2O_5	.65	.10	.92	1.04
CO_2	.39			
SO_3	.28			
Cl	.07			
H_2O	1.10	.58	.45	2.04
	99.84	100.09	100.63	99.92

Nordmarkyte. This rock was described under the head of granitoid trachyte by Logan (Geology of Canada, 1863, p. 653) as "being made up in a great part of a crystalline feldspar, with small portions of brownish black mica, or black hornblende, which are sometimes associated. The proportion of these minerals is never above a few hundredths, and is often less than one-hundredth. The other mineral species are small brilliant crystals of yellowish sphene, and others of magnetic iron, amounting together probably to one-thousandth of the mass."

To the essential minerals there should be added a nearly colorless augite, which commonly equals the hornblende in amount and is a rather more persistent constituent of the rock. The feldspar is almost wholly a microperthite, which as the following analysis by Hunt (Geology of Canada, 1863, p. 476) shows, answers approximately to an isomorphous mixture of albite and orthoclase molecules in the proportion of 3:2.

I. Feldspar, Shefford. Analysis by Hunt.

II. Kryptoperthite, Laurvik, Norway. Analysis by Emelin, Syenitpigmatitgange, p. 524.

III. Anorthoclase, Marblehead Neck, Mass. Analysis by Chetard, Bull. Mus. Comp. Zool., XVI.

IV. Approximate theoretical composition of feldspar having the formula Ab_3Or_2.

	I	II	III	IV
SiO_2	65.15	65.90	65.66	67.06
Al_2O_3	20.55	19.46	20.05	19.00
Fe_2O_3		.44	trace	
FeO			trace	
MnO			.13	
CaO	.73	.28	.67	
MgO			.18	
K_2O	6.39	6.55	6.98	6.93
Na_2O	6.67	6.14	6.56	7.00
H_2O	.50	.12	2.19	
	99.90	98.90	100.64	99.99

Augite in this rock commonly occurs in stout columnar crystals and in ordinary light is either colorless or slightly greenish, without perceptible pleochroism. It is frequently associated with smaller grains of magnetite and both may enclose needles of apatite. Hornblende in the thin section is green or yellow in ordinary light, never brown as in essexyte. Sections parallel to $\mathfrak{c}$ = deep green; $\mathfrak{b}$ = yellowish green; $\mathfrak{a}$ = straw-color. 26° was the greatest value found for $\mathfrak{c} \wedge$ c.

Biotite polarizes in unusually brilliant tints, probably indicative of a larger proportion of iron than usual in its composition. Sphene is frequently quite an abundant accessory and occasionally a few grains of quartz are seen.

In structure the rock is coarsely granitic. The absence of quartz in sufficient amount to form a cementing material for the other constituents tends to render it friable on exposure to the atmosphere. It is easily disintegrated and, where protected from heavier glaciation, is often reduced to a loose mass of rectangular grains of feldspar for several feet in depth.

It will be seen from the above description that this rock bears a close resemblance to some of the syenyte types of southern Norway which have been made classic by the work of Prof. W. C. Brögger. Compared with thin sections of laurvikyte from Frederiksvarn, or in other cases with nordmarkyte from Christiana, the only discernible differences are that feldspar from Shefford is microperthite, rather than kryptoperthite, and that a "schiller" structure frequent in the augite of the laurvikyte is not seen in that from Shefford. The first mentioned difference is only one of the texture of the albite-orthoclase intergrowth, for, as has been shown by the

chemical analyses already quoted, the minerals are practically identical in composition while the "schiller" structure is merely a structural difference which may at least be of secondary origin. From its chemical affinities as shown in the following analyses, however, the rock is classed as nordmarkyte.

	I	II	III	IV
SiO_2	65.43	64.04	64.63	65.43
TiO_2	.16	.62		.50
				ZrO_2 = .11
Al_2O_3	16.96	17.92	18.15	16.11
Fe_2O_3	1.55	.96	3.05	1.15
FeO	1.53	2.08		2.85
MnO	.40	.23	1.00	.23
CaO	1.36	1.00	1.54	1.49
BaO	none			.03
MgO	.22	.59	.50	.40
K_2O	5.36	6.08	4.79	5.97
Na_2O	5.95	6.67	5.80	5.00
P_2O_5	.02			.13
CO_2	none			trace(?)
SO_3	.06			F = .08
				FeS_2 = .07
Cl	.04			.05
H_2O	.82	1.18	1.08	.89
	99.86	101.37	100.54	100.18

I. Nordmarkyte, Shefford. Analysis by Connor.

II. Nordmarkyte from Tonsenus, Norway. Cited by Rosenbusch in "Elemente der Gesteinslehre."

III. Quartz Syenyte, Dike Rock, Fourche Mt., Arkansas. Analysis by Brackett, Described by J. H. Williams.

IV. Syenyte, Mt. Ascutney, Vermont. Analysis by Hillebrand, U. S. G. S. Bull., 148. Petrographic data by Daly and Jaggar.

Pulaskyte. This rock is somewhat variable in appearance passing from a gray and somewhat porphyritic trachyte-like rock in the central part of the mass to a greenish and more distinctly porphyritic rock along its margin. Small crystals of black hornblende and larger ones of feldspar can often be seen in the feldspathic ground mass. By the aid of the microscope the feldspathic phenocrysts are found to consist of both orthoclase and plagioclase. The former appears to predominate in the interior, while towards the exterior of the mass plagioclase becomes more abundant, a variation that seems to be analogous to that described by Cross* in the Game

*Geology of Silver Cliff and the Rosita Hills, Colorado. WHITMAN CROSS, *17th An. Rept., U. S. G. S.*, p. 306.

Ridge trachyte of the Rosita Hills, Colorado. Hornblende in this rock is chiefly green in ordinary light as seen in the thin section, though a few of the largest crystals are brown resembling the hornblende of the essexyte, while the green is like that of the nordmarkyte. Both are trichroic with the same scheme of absorption, viz.: $\mathfrak{c} > \mathfrak{b} > \mathfrak{a}$ and extinction angles as high as 26°-27° have been observed in sections in the zone of the clinopinacoid. Augite when present is of the colorless variety described before.

Biotite occurs in large individuals but is on the whole less abundant than hornblende. The groundmass consists chiefly of short rather stout prismatic sections of feldspar which have a parallel extinction and are packed together in a close and nearly parallel arrangement, with a little allotriomorphic feldspar in the interstices. A little undetermined matter occurring interstitially amongst the feldspars was thought to be altered nepheline. It may, however, be only kaolinized orthoclase. A few striated sections appear which extinguish at low angles with the twinning lines and are probably oligoclase. They are unimportant in amount. The texture of the rock was found too fine to admit of a mechanical separation.

Its mineralogical and structural characters at once suggest the affinity of this rock to pulaskyte, first described by Mr. J. F. Williams* from Arkansas, a view that is also corroborated by the results of its chemical analysis. In the hand specimens it is generally somewhat lighter in color and finer in texture than the specimen of pulaskyte in the educational series of the United States Geological Survey at the petrographical laboratory of McGill University, and judging from the published description it is very similar to the porphyritic syenyte from Saline county, Arkansas.* This, however, was considered by Williams as scarcely to be distinguished from pulaskyte, occupying the same position amongst the igneous rocks of Saline county that pulaskyte holds at Fourche mountain.

A variety of this rock in which hornblende and augite are replaced by aegirine-augite approaches very closely to the sil-

* The Igneous Rocks of Arkansas, J. F. Williams, Ann. Rep. Geological Survey of Arkansas, Vol. II, 1890.

[illegible] and seq.

vsbergyte type. It is apparently closely related to the acmite-trachyte of Profs. Wolff and Tarr. (Bull. Mus. Comp. Zool., Cambridge, 1893) afterwards re-named by Prof. Wolff as tinguayte, var. sölvsbergyte. In that rock, however, the bisilicates are in the form of ægerine and augite intergrown, instead of a single mineral of intermediate composition as at Shefford.

	I	II	III	IV
$Si\,O_2$	59.96	60.03	59.01	58.70
$Ti\,O_2$	.66		.81	trace
$Al_2\,O_3$	19.12	20.76	18.18	19.26
$Fe_2\,O_3$	1.85	4.01	1.63	3.37
FeO^2	1.73	.75	3,65	.58
Mn O	.49	trace	.03	.10
Ca O	2.24	2.62	2.40	1.41
Ba O	.12			
Mg O	.65	.80	1.05	.76
$K_2\,O$	4.91	5.48	5.34	4.53
$Na_2\,O$	6.98	5.96	7.03	8.55
$P_2\,O_5$	.14	.07		.10
$C\,O_2$	none			
$S\,O_3$	.08	none		
Cl	.14	none	.12	
H_2O	1.10	.59	.50	2.57
	100.17	101.07	99.98	100.00

I. Pulaskyte, Shefford. Analysis by Connor.

II. Pulaskyte, Fourch Mountain, Arkansas. Analysis by Brackett and Smith.

III. Umptekyte, Red Hill, Moultenborough, New Hampshire. Cited by Rosenbusch, loc. cit.

IV. Sölvsbergyte (Acmite Tracheyte), Shield's River, Crazy Mountains, Montana. Analysis by Melville. Described by Wolff and Tarr.

Contact Facies.

The endomorphic contact facies of each of these rocks is marked by an increase in the proportion of the ferromagnesian constituents and the appearance of nepheline and sodalite amongst the accessory constituents. The essexyte thus becomes a very dark rock of which hornblende alone sometimes makes up about one-half and frequently approaches very nearly to the character of theralyte. The nordmarkyte shows also a great increase of the basic constituents, especially biotite. The feldspar too changes from microperthite to krypto-

perthite and plagioclase becomes a noticeable constituent. As in the essexyte a little nepheline, usually quite decomposed, and a blue sodalite appear. The latter occurs in strings amongst the feldspars and like the nepheline was one of the latest minerals to crystallize. Some contact features of the pulaskyte have already been mentioned and, like those of the other two rocks, indicate an increased basicity in the peripheral portions of the mass.

Later Dykes.

Besides dykes of the various classes of rocks which constitute the main mass of the mountains there are many of later age which are themselves of at least two different ages of intrusion. They were distinguished in the field as the light colored and the dark colored dykes, a distinction which detailed study proved to be a natural one. The dark colored dykes were found to be intersected in numerous instances by the light colored ones and no case of the reverse has been found. Hence they are undoubtedly the older. The later or trachytic class become in a few cases quite free from bisilicates, have the trachytic structure less pronounced, and so pass into bostonyte, while the earlier series are chiefly lamprophyres. Some are of the camptonyte type, while others occasionally assume a more plutonic character and by the addition of nepheline in essential amounts pass into a hypabyssal form of theralyte.

Magmatic Relations.

The complementary nature of the dykes as well as of the rocks of the first and second irruptions seem to indicate beyond question that the igneous rocks of Shefford are only slightly differentiated products of a single magma. The splitting up of an alkaline magma into dykes of the camptonyte and bostonyte series is too well known to require comment, and in the absence of chemical analyses it can only be said that their presence indicates an original magma of medium basicity.

But in the case of greater and consequently the much more important masses, it is interesting to note that the pulaskyte, the latest of the three intrusions, stands as an almost exact mean in chemical composition between the essexyte and nordmarkyte of the first and second irruptions. Hence lay-

ing aside quantitative calculations of the output of these two rocks, or considering them equal, which may reasonably be done, the chemical character of the primary magma was about that of the pulaskyte.

For convenience in reference their chemical analyses are repeated with the mean between the essexyte and the nordmarkyte.

	I	II	III	IV
SiO_2	53.15	65.43	59.96	59.290
TiO_2	1.52	.16	.66	.840
Al_2O_3	17.64	16.96	19.12	17.300
Fe_2O_3	3.10	1.55	1.85	2.325
FeO	4.65	1.53	1.73	3.090
MnO	.46	.40	.49	.430
CaO	5.66	1.36	2.24	3.510
BaO	.13	none	.12	.065
MgO	2.94	.22	.65	1.580
K_2O	3.10	5.36	4.91	4.230
Na_2O	5.00	5.95	6.98	5.475
P_2O_5	.65	.02	.14	.335
CO_2	.39	none	none	.195
SO_3	.28	.06	.08	.170
Cl	.07	.04	.14	.055
H_2O	1.10	.82	1.10	.960
	99.86	99.84	100.17	99.850

I. Essexyte.
II. Nordmarkyte.
III. Pulaskyte.
IV. Mean between Essexyte and Nordmarkyte.

In order of intrusion the successive chemical variations have accordingly been:

1. More basic than the pulaskyte magma = essexyte.
2. More acidic than the pulaskyte magma = nordmarkyte.
3. The normal, or pulaskyte
4. More basic = Camptonyke dykes.
5. More acidic = Bostonyte dykes.

PALEONTOLOGICAL SPECULATIONS.

II.

Biological Crises.

By L. P. GRATACAP.

(Continued from Vol. XXVII. p. 75.)

Surveying a paleozoic series of fossils the student is impressed with the recurrence of periods of great fecundity or, more exactly, for it does not have reference to mere individual multiplication, periods of especial creativeness. A horizon is encountered when the rocks suddenly (?) swarm with related forms of life, quite manifoldly developed. They represent those moments, in the survey of a cabinet, when the visitor finds the sort of animal life (presented as fossils) expanding over a number of shelves or even cases, which, in related forms, are elsewhere found limited to one or a few.

Such are for instance, the numerous specimens of *trilobites* in the Upper Cambrian, the *Cystidea* in the Upper Silurian, the *lamellibranchs* in the Devonian, the *crinoids* in the Lower Carboniferous. It would be preposterous to call these ocurrences unannounced, but they have some of the character of surprises.* Dr. Hall (Preliminary Notice of the Fauna of the Potsdam Sandstone) in speaking of the remains of primordial trilobites in Wisconsin and Minnesota alludes to their great numbers; "the material consists of glabellae, separated cheeks, caudal shields, and fragments of thoracic articulations either lying separately or crowded together, sometimes forming the principal part of layers one or two inches or more in thickness."

Developed with these were the great numbers of inarticulate brachiopods, so that in individual enumeration, as Owen has remarked, the "number is immense; some slabs so covered with shells, that it would be difficult to place the finger on a spot without touching some of them," and in less than 500 feet, a recurrence of six trilobite beds.

The variation and wealth of specific forms is well indicated in Whitfield's remarks on his own species *Crepiceph-*

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*Lapparent has indeed used the expression, in speaking of this primordial fauna, "l'eclosion, *qui semble presque subite*, de la remarquable faune de crustaces a laquelle Barrande a donne le nom de faune primordiale."

alus onustus (Geology of Wisconsin, Vol. IV, p. 183) where he writes, "there seems to be an almost endless variety of this group of trilobites preserved in the rocks of this period, differing principally in the combination of features as shown in the cephalic shield. The numerous species are* readily recognized, however, by the form of the fixed cheeks and glabellas, even where no other part of the animal can be determined; and though it may appear incredible, entirely new forms are presented among the specimens obtained from each individual locality."

Dawson, Hartt and Matthews have similarly indicated the abundance of trilobitic remains in the Acadian fauna at Ratcliffe's Mill-stream, St. Johns, and elsewhere in New Brunswick, "where some of the layers are perfectly loaded with fragments of trilobites."

Matthew also says in his paper on the "Fauna of the St. John group" (Transactions Royal Soc. of Can., 1891, p. 55) "in the black slates of the Bretonian Division there are locally immense numbers of minute trilobites which appear to represent in the economy of nature the swarms of Agnosti that are found in the fine shales of the Acadian division and were there buried in the fine mud that entombed the Paradoxides."

The language of Barrande is well known (Systeme Silurien de la Bohême, Vol. I, Suppl., p. 397) "sous le rapport de la frequence des individus, on sait que dans toutes les contrées où la faune primordiale est connue, les restes des trilobites, paraissent innombrables tandisque les traces des autres fossiles sont rares. Ainsi, en Bohême on peut estimer la fréquence des trilobites, comme au moins centuple de celle de toutes les autres formes fossiles. Cette estimation est probablement beaucoup audessous de la vérité. D'apres les descriptions des savans, il en est à peu pres de meme dans toutes les autres contrées, sur les deux continens."

The researches of Walcott and MM. Brögger & Schmidt have now definitely aided paleontology in establishing three zones or faunal expressions to the Cambrian day, the Olenellus (annelidan), Paradoxides, and Olenus. The vertical separation, in sediments, of these beds is represented in

*Nous n'y trouvons cependant ancum type de trilobite que l'on puisse considerer comme appartenant a une famille distincte de ceux des couches a *Paradoxides*.

thousands of feet, and in similar zones the separation of different beds is almost as great, yet the biological expression is not extremely contrasted throughout and, as the French translator of Matthew's paper has remarked* (Soc. Mal. de Belgique; Ann. 4th, 1888, p. 552), the lowest beds holding the earliest trilobites offer no significant evidence, in their trilobitic remains, of embryonic or formless stages of development. That is while larval conditions may appear they are stages in an individual life history, not fixed preparative stages in the development of a phylum.* It is logical, or at any rate natural to assume that throughout the long periods of time antecedent to the Cambrian age these preparative stages were evolved and completed, but as a matter of contemporaneous geological history they have not yet been discovered, and possibly, from their perishable nature, cannot be. The trilobites of the Cambrian in their numerical abundance, their very considerable specific variation, their sudden appearance in the paleontological series, and their apparent chronological isolation justify the characterization of a *biological crisis.* The only way to throw light upon this problem is to consider the circumstances of similar biological multiplications and intensity in living faunas.

It would seem certain that the trilobites enjoyed an almost complete immunity from those accidents which today devastate the young broods of crustaceans, while the almost infinite resources of multiplication with which this phylum is endowed permitted unrivalled opportunity for propagation and distribution. Profs. Sars and Boeck have pointed out the numerous dangers to which the young lobster is exposed and which must necessarily greatly reduce the total numerical maximum attainable by that animal. The young larval lobster suffers from the attack of fish, the entangling effect of sea-weed, the injurious physical character of the coast, whither currents may transport them, sudden changes of temperature,† and impaired vitality from abrupt or delayed discharge from the parent.

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*There can be of course, no demurrer to the conclusion that many genera of Cambrian trilobites, perhaps the more common and generally noted, represent protaspic stages in more advanced and later evolved genera, but as found they are mature defined and individualized genera. Dr. Beecher has indeed said that the Opisthoparia (Conocoryphidae, Olenidae, Asaphidae Lichadidae, etc.) probably culminated during the Cambrian.

†Although in 1879 lobsters with roe were successfully transported to the west coast and "had with them over a million eggs nearly ready to hatch," yet no results have apparently flowed from the experiment.

Fish were absent in the Cambrian seas, mollusca had reached no formidable growth, the shores were devoid of excessive algous occupancy, and probably thermal conditions were benign.

If we assume for the trilobite the fecundity of the ordinary crustacean, which in the lobster presents a phenomenal intensity since to the enormous number of ova in a female, the practical impregnation of every egg superinduces an almost unparalleled generative success, and if we add to this the most optimistic circumstances of its environment, the great development, wide distribution, and individual numbers of the Çambrian trilobites does not seem so extraordinary. In other words a *biological crisis* is coincident with the period of greatest internal and external harmony. When with the congenital forces of procreation, the physical factors are so encouraging and sympathetic as to give them their extreme amplitude of action, the zoological result must at least be surprising.

In Semper's contributions to the influence of surroundings upon the animal organism (International Science Series, 1881) he has pointed out the varying influences of food, temperature, atmosphere, water motion, currents, subsidence and upheaval, ocean waves, pressure, and the influence of living surroundings. Amongst these for the purpose of realizing the possible biological results amongst the trilobites of the Cambrian we may select food, temperature, water motion, currents, land movements and living surroundings. These must all have been reasonably favorable, and we can from geological evidence establish their probable coexistence and reinforcement.

The crustaceans of the sea today feed upon algae and young marine animals. The Cambrian sea doubtless furnished algae in abundance of a unicellular type but more especially there is reason to think that protozoon, metazoon, and coelenterate life was omnipresent, and if the contention raised in the former section of this paper that the sea shores witnessed the earliest evolution of marine life, here rhizopods, sponges, medusæ, jelly-fish, anemones, today voraciously eaten by lobsters and crabs would have abounded

and furnished an unlimited food supply to the somehow rapidly advanced type of crustacean life.*

Granted that the food supply was abundant Semper's statement directly applies. He says (p. 65) "it is self-evident that an optimum of nutrition can alone insure the normal functions of all the organs; if it does not attain the optimum, the functional activity of *all* the organs is impaired; modifications at the same time occur in their structure, *i. e.*, the animals grow leaner because incapable of exercising their sexual functions, etc." The sexual powers of the Cambrian trilobite so far as food strengthened or increased them were probably well developed.

Temperature was propitious. It has been over and again demonstrated that warmth vitalizes the generative functions. There is a wide range of differing capacitv in this respect in animals, and the familiar term *eurythermal* has been applied to those organisms which endure contrasted temperatures.

But the fact is almost universal that heat is stimulating and helpful, to animal life and its functions. It has been observed that snails of the warm Mediterranean region are quickly brought to sexual maturity and that "species of the same genera, perhaps even the same species, in damp and cold climates do not produce a new generation until they are fully grown while in the dry warm region of the Mediterranean they have produced two generations before they are fully grown" (Semper). Semper has himself observed that the larvæ of *Branchipus* and *Apus* hatched out in less than twenty-four hours at a temperature of 30° Cent., but at 16°-20° they required some weeks.

Today our shore crustaceans require the warmth of summer to bring their powers of fecundation into activity, but it can readily be understood that the Cambrian trilobite in an equable and hot climate, such as in all probability, and, as almost universally recognized, prevailed at that period, may have excluded two broods or more in the seasonal year, while the rapidity of development of the larvæ into mature forms, and their early acquirement of sexual activity may have still

*The omnivorous propensities of the modern crayfish, have been characterized by Huxley, "few things in the way of food are amiss to the crayfish; lividg or dead, fresh or carrion, animal or vegetable, it is all one." Trilobites are not crayfish, but it is reasonable to infer that the elements of nutrition in the whole group of crustacea are not dissimilar throughout.

further reinforced the numerical results. It was a time when as at the Philippine Islands today, true periodicity had disappeared, and eggs, larvæ, and propagating individuals may have been found at all times.

The remaining factors that might have influenced the successful development of trilobites in the Cambrian seas were water motion, currents, land movements, and living surroundings.

The prevalence of high waves, the rushing in and out of heavy volumes of water, would have been extremely detrimental to the lives and propagation of crustacean animals if they were exposed to its mechanical violence and its accompaniment of moving stones etc. But the evidence points to the occupancy of shallow shores or basins by the Cambrian trilobites and those generally of a sandy or muddy nature, in which no disturbances inimical to their quiet and continuous existence appeared. The conditions of a slowly advancing or receding sea (vide Chamberlain, Jour. of Geol., Vol. VI, p. 449) permitted their enormous multiplication along the thermally benign coast areas, while the absence of rapid or destructive currents seems certain from the usually conformable and exact lamination of the beds where the trilobites occur in large numbers.

Finally their living surroundings were almost invariably favorable, food was abundant and enemies absent. Their specific and generic variations are not so easily explained. They certainly point to an inheritance of characters developed far back of the Cambrian day, characters also quite deeply established, and ineffaceable by interbreeding or pan-mixia.

The Cambrian faunal trilobite expression is that of a broad anterior shield more or less genally extended, a conoid head, an extended series of pleural segments, and a reduced or absent pygidium. Their separation into species and even genera suggest inherited anomalies in their evolution from the annelid (Bernard), and even point to divergent origins from differing annelid types. Bernard (Quar. Jour. Geol. Soc., Vol. 50) has described trilobites "as fixed specialized stages in the evolution of the Crustacea from an annelidan ancestor, which bent its mouth round ventrally so as to use its parapodia as jaws." Now it seems inconceivable that if evolution brought about this

change a single individual annelid or one restricted form of annelid started the process. However conceived, a number of forms or annelidan individuals gradually began this curious change, and it can be safely emphasized that such a change was not *begun* under the impulse of *natural selection,* since the turning under of two, three or four segments (somites) of a worm-like organism, so as to bring its mouth against its ventral surface would hardly prove a favorable position for competition with more extended and pliant congeners.

If the inflection of the annelid body began at several distinct localities simultaneously the stages of evolution may not always have been the same; were not likely to be. And if this was so, there seems to be no need of presupposing even a geographical connexion between separated geological areas, having similar species of trilobites; as the evolutionary stage might have, must have, eventuated at many places or more than one place, at the same time. The hypothesis of a single annelidan ancestor for the trilobites, or even many *identical* ancestors seems inadvisable, and the hypothesis of a single center of origination and distribution even more so.

But examining the Cambrian trilobites the impression deepens that the influence of environment and habits is discernible, and that in the case of *Dikelocephalus, Aglaspis,* and *Crepicephalus,* something like natural selection is hinted at. For in the first instance, that of the influence of environment and habits, it is seen in the assumption of the broad cephalic and genally rounded shield. The first form of the cephalon of the involuted worm would naturally have been in an inflated rhombic outline and the gradual development of an expanded crescentic and more flattened shield an adaptation to its new habits and new surroundings. It is further safe to assume that the evolution of a trilobite from a worm, began in the larval stages of the latter in order to preclude the almost impossible thought of a *fixed* mature organism undergoing changes that would so react on its own embryology as to establish there a new series of metamorphoses. Take for instance the larval stage of the worm *Polygordius,* when from the enlarged cephalic mass the segmented body elongates, does not a condition supervene which might readily give or has given rise to a trilobitic phase?

However that might be the primordial trilobites seem, as the earliest crustaceans, a good illustration of the influence of environment. They lived in shallow seas, along sandy shores, and occasionally in muddy and calcareous slimes. But in their motion over the sea bottoms or their occasional excursions into deeper water they constantly encountered an opposing pressure and the effect of mechanical resistance, in accordance with the principles of histological modifications enunciated and established by Ryder, would have hastened the growth of the trilobitic head-shield. Ryder has written of the hard exoskeleton of chelonians and armadilloes,* "the origin of dermal ossifications is to my mind rationally explained by supposing the bioplasm of each dermal cell as sensitive and irritable to rude or violent external impacts, which, oft repeated, act as stimuli of growth force, determining certain tracts of these cells as the nidus within which osseous particles eventually appear as nuclei of the future defensive dermal bony system." The same theorem has received discussion in Prof. Cope's well known address on "Relation of Animal Motion to Animal Evolution," and a capital illustration of one phase of it is found in the strengthened lateral teeth in the plates of Chitons exposed to the mechanical violence of waves. (See Pilsbry.)

The change from a creeping habit to a swimming one would have, in accordance with this law, developed a hardening chitinous envelope over the head parts of the metamorphosing annelid, wherever the stimulating effects of pressure, against water, sand, or mud, were felt. Environment and habit, on the assumption of an annelidan origin, must have had a sensible influence in producing primarily the crescentic shield-shape of the trilobites glabella.

Natural Selection may have played some part in the rapid extermination of *Dicellocephalus, Aglaspis* and *Crepicephalus.* They are found with an extremely limited range, and, in the appreciable vertical distribution of *Dicellocephalus,* the occurrences are sporadic. Broad expanded shields or blunt shouldered ones would have generally proved unfavorable to continued existence along a stormy or tide invaded coast. In the former case their owners in shallow water would have been

*On like Mechanical Conditions as producing like Morphological Effects. Amer. Nat., 1878, p. 157.

readily overturned and drifted up upon the beach, and the difficulty of returning to their normal position increased by the flatness and width of their frontal carapace.

Today the awkward and prolonged efforts of a Limulus to return to its normal position when upside down are finally rendered successful by the assistance of its telson. It can be pointed to as illustrating an effectual line of development which might have assisted the primordial trilobites, viz., flat and sloping heads, features absent in Dicellocephalus, Aglaspis, Chariocephalus, Crepicephalus &c.

Again it seems probable that the extended pleural segments of the primordial trilobites were correlated with a weak articulation. This early crustacean failed in rigidity and coherence. It fell apart easily upon impact or collision or exposure. The line of favorable development in this case which would have strengthened the trilobite was in the direction of a shortened thoracic extent and an increased pygidium. But the surfaces of attachment for egg sacs were multiplied in the Cambrian multi-pleural forms and the intensity of multiplication was thereby augmented.

From the early Cambrian Olenellus and the Paradoxides through Conocoryphe and Ptychoparia etc., to the Agnostus, Illaenus etc., there is an evident relative shrinkage in the cephalic shield, a condensation of the pleuræ, a loss of pleural spines, a growth of the pygidium, all organic movements in the direction of strength and solidity. Environment and habit and selection played important parts in aiding a determined development, but the remarkable and overshadowing importance of crustacean life in the Cambrian day must have resulted from an optimum in the conditions then favorable to their growth, and from the ease also with which evolutionary processes formed them from an annelidan ancestor.

This latter observation deserves a moment's clearer consideration. The development of a trilobite from an annelid would have been, humanly speaking, a more natural and hence a more quickly completed change than that of a brachiopod from the same original organism. If such evolutionary processes began at the same time, at a given period, subsequent to their inception, the trilobite phylum might have been numerously represented, when as yet the brachiopodous life had formed

but slightly. In the evolutionary change from one organic form to some possible organic deduction from it, the generative organs are probably the last to become fully habituated to an altered form and nature. There would certainly be less violent change from the generative functions of a worm to those of a trilobite than from the same to those of a brachiopod, and along some line of elucidation like this we may partially explain the early preponderant profusion of trilobitic forms.

Another instance of a *biological crisis* is the abundance of lamellibranch remains in the Upper Devonian in the Hamilton and Chemung rocks of New York. There is presented in the New York Hamilton, an extraordinary development of lamellibranchs exhibiting a marked and almost sudden display of genera which continues with an increased numerical intensity and a noticeable similarity of types into the Chemung, to be practically obliterated in the Lower Carboniferous. The phenomenon seems also to distinguish an optimum of conditions for growth and variation, and, as in the case of the trilobites, must have resulted from a conjunction of a favorable environment and vital force. There is certainly a well marked development of bivalves in the Devonian and along with the appearance of new genera, a multiplication of species and an immense increase in individuals.

In the studies of paleozoic lamellibranchs so carefully prepared of the N. Y. Geological Survey, though unfortunately incomplete, a tabulation of the species from the different geological horizons from the Schoharie to the Waverly affords this interesting summary:

Schoharie	Corniferous	Marcellus	Hamilton	Genessee	Portage	Chemung	Catskill	Waverly
16	41	21	174	2	9	252	1	35

The showing of species for the Waverly is misleading. In the Preface (Vol. V, pt. I.) the authors (Drs. Hall and Beecher) explain the comparatively few species from this horizon as due to delay, interference, and their solicitude to bring their work to completion and publication.

The decreased number of species in the Waverly may therefore not be of much significance, but the evident fact of a progression forward from the Corniferous, the unquestioned lamellibranchiate evolution of increased numbers and species to the Chemung and the obvious gaps between the Corniferous and Hamilton, the Hamilton and Chemung, the Chemung and Waverly are.

Such gaps are an evident indication of a suspension of molluscan life incident upon unfavorable conditions and the withdrawal of the previous molluscan faunas elsewhere, as there can be no doubt of the continuity of this lamellibranchiate life through the Upper Helderberg, Hamilton and Chemung periods. Those conditions were shore conditions, shallow water, continental drainage and more or less disturbed marine tracts wherein storms or waves easily dislodged shells, and caused their withdrawal to deeper water. On the other hand the increase of species in the populous periods after these gaps, would seem to indicate an acceleration' in the production of species, which must have begun in some areas to which the molluscan fauna retreated upon the invasion of their previous habitat by the conditions represented in the Marcellus, Genessee, Portage and Catskill.

The Marcellus group certainly does not represent a period totally inimical to molluscan life. It only marks a decresence of the previously crowded fauna of the Upper Helderberg and holds within it (Clarke, Livonia Salt Shaft, 13th Annual Report, N. Y. State Geologist, p. 156-158), a succession of faunas which are both reminiscent and prophetic, being Helderbergian and Hamiltonian in nature, besides its own indigenous fossils. The Marcellus, as the Genessee, presents, however, an instructive illustration of displacement and conflict. It introduced conditions, and brought with it a life contrasted with the conditions and life which marked the Upper Helderberg, and yet in those conditions and life there remained a struggling survival of the latter, and many of the lamellibranchiate genera pushed their way through to the Hamilton, while on the other hand the Hamiltonian fauna moving landward inserted itself "*prenuncially*" (Clarke) in the Marcellus areas.

Similarly in the Genessee, outside of the fundamentally characteristic "*intumescens*" fauna, the relics of Hamilton life,

and the precursors of Chemung life are found. But in both these cases we are evidently in the presence of oscillating conditions; we have shown us again, what seems so universal and constant a predicament in the geological record, an extending continental margin with a previous deeper sea life pushed away from the continental sediments and existing under stress and competition (See Chamberlin, Jour. of Geol., Vol. VI, p. 449.) in narrower precincts, itself surging back again upon the continental shelf, somewhat modified by its long absence, when the deeper water conditions supervene nearer the land surfaces. Yet if the shallow water character of the Marcellus and Genessee is conceded the presence in both of ammonoids seems contradictory. Dr. Clarke (50th Ann. Rep. Regents, p. 137) insists that in the Genessee these goniatitic remains are "not a mechanical invasion, a congeries of flotation, but is in harmony with its components in mode and direction of derivation." Deferring a longer reference to that fact, and reverting again to the disappearance, sometimes partial only, of the lamellibranchs in the Marcellus and Genessee, we must conclude that the shallowing of the water was not an entirely determinate cause expelling them, but that some associated feature in the character of the water, or bottom, brought it about more explicitly. This feature may be the widely disseminated bituminous contents of these shales. There seems to be evidence that this bituminous matter was, to some extent at least, derived from the land and that it was disseminated through the water probably coincident with land storms, bringing on inrushes of fresh water, and overwhelming accessions of mud.

It is well known that in the development of oysters, clearness of water, permanence and hardness of bottom, still and undiluted marine conditions favor the survival of the young. And this is also true of other bivalves. Mr. R. E. C. Stearns in his suggestions as to the best means of transplanting the edible bivalves, (*Glycimeris, Saxidomus, Schizothoerus*) of the Pacific coast to the east, has stated that such conditions should be measurably secured, though in the case of some of these shells, slime, alluvium, drainage and refuse matter did not actually exterminate, or even diminish them. Of course the Marcellus conditions if unfavorable to an expansion of lamel-

libranchiate life were not faltal at all to its continuance. *Panenka* and *Lunulicardium* survived in both the Marcellus and Genessee and Portage.

If then the Marcellus, Genessee and Portage were marked by a diminished lamellibranchiate life, and if this diminution arose from the too strong prevalence of shore conditions; floods, suffusion of particles, dirtv water, brackish currents, sand-flats, tidal extremes etc., what does the general continuance of the lamellibranchs and their increase from the Upper Helderberg to the Waverly signify?

Such a continuance in genera, as the following table shows is unmistakable.

TABLE OF GENERA

UPPER HELDERBERG	HAMILTON	CHEMUNG
Aviculopecten	Aviculopecten	Aviculopecten
	Actinopteria	Actinopteria
	Allocardium	
Conocardium	Conocardium	Conocardium
	Cytherodon	
	Cimitaria	Cimitaria
Cypricardinia	Cypricardinia	Cypricardinia
		Crenipecten
Dystactella	Dystactella	
		Edmondia
		Ectenodesma
	Elymella	
Glyptodesma	Glyptodesma	
	Gosselettia	
		Glossites
	Goniophora	Goniophora
Grammysia	Grammysia	Grammysia
Lyriopecten	Lyriopecten	Lyriopecten
Leiopteria	Leiopteria	Leiopteria
	Leptodesma	Leptodesma
Limoptera	Limoptera	
	Leda	
	Lunulicardium	Lunulicardium
Mytilarca	Mytilarca	Mytilarca
		Modiola
Modiomorpha	Modiomorpha	Modiomorpha
Microdon	Microdon	Microdou
	Modiella	
	Macrodon	Macrodon
Megambonia		
	Nucula	Nucula
	Nuculites	
Nyassa	Nyassa	
	Orthonota	
Palaeopinna		
Pterinopecten	Pterinopecten	Pterinopecten
Pterinea	Pterinea	Pterinea
Panenka	Panenka	
Paracyclas	Paracyclas	Paracyclas

Pararca		Pararca
	Palaeoneilo	Palaeoneilo
	Prothyris?	
		Ptychopteria
		Pteronites
	Phthonia	
	Pholadella	Pholadella
	Ptychodesma	Ptychodesma
	Palœanatima	
	Palaeomya	
		Prorhynchus
	Solemya	
	Sphenotus	Sphenotus
Schizodus	Schizodus	Schizodus
	Solen	
		Sanguinolites
	Tellinopsis	

The genera of the Upper Helderberg are twenty-one, of the Hamilton forty-three, and of the Chemung thirty-five. There is a sensible identity in the genera of the last two formations, with an increase of species in the Chemung. There would seem to be indicated here a biological crisis; that a group of organisms enormously expanded under favorable circumstances, and that when they were forced out of their habitats, they came into competition with each other in a smaller environment, and upon each return, brought back an increased number of species, possibly referable to that competition as a cause.

As in the case of the trilobites, this crisis suggests something like *impulse, vis a tergo,* assisted indeed by natural auxiliary conditions. There would seem to be no especial reason why, from the Potsdam to the Devonian, the lamellibranchiate phylum, which was certainly in evidence throughout that long time, might not have reached as wide a circumscription of species and genera as it did in the last named era, any more than there seems any special reason why the trilobites in the Cambrian attained a development quite unrivalled since. It has been suggested in this paper that evolution could have acted more rapidly in the production of trilobites than it did in the associated life, reinforced by very favorable circumstances for their multiplication. Can it be conceived that in the case of the lamellibranchs there were inherent obstacles to evolution, and a protracted restraint ensued before this life group could store up enough biological spring to jump forward into formal (generic and specific) diversity? Is evolutional aptitude, like individual endowment

in men, a function of organization? Or is all evolution conditioned upon physical circumstances. In many ways it must be, and perhap this long quiescence of potential variability in the lamellibranchs proves it.

At any rate we are afforded a glimpse at a cause for variation in the succession, shown in the New York palaeontological studies, of the Devonian bivalves. It is this.

The recession of the sea causing the shallow water formations of the Marcellus, Genessee, Portage, Catskill, was always succeeded in the Hamilton, Chemung, and probably Waverly, by an increase of species. It would then appear probable that the expelled genera in each instance, driven to more restricted areas, probably in deeper water, came into some sort of competition, and species, as fixed variations, were stimulated to appear, and in the next encroachment landward multiplied. Comparing the Chemung with the Hamilton the genera prominently exhibiting this expansion are *Pterinea, Antinopteria, Leptodesma, Glossites, Mytilarca*, with the new genera *Crenipecten, Ptychopteria Edmondia.* These genera and their species give some evidence of deeper water origin in their smaller size. Naturally this statement cannot be made into a sweeping deduction, but it has a preponderant application. The large sized genera *Limopteria Glyptodesma* are Hamilton, the small sized genera *Crenipecten Edmondia* are Chemung, and throughout, with many exceptions, the impression of the Chemung species is that of smaller sized individuals. The voyage of the Challenger lends support to this view and Sir Wyville Thompson has himself said "my present impression is that although life is thus universally extended, the number of species and of individuals diminishes after a certain depth is reached, and that at the same time their size *usually decreases.*"

If the increase of species has resulted from competition in circumscribed sections of the sea-bottom, this crowded condition may have had also some influence on size.

The assumption of recurrent periods of competition with the consequent multiplication of species introduces what has always seemed a difficult inquiry, how the process of the *survival of the fittest* works amongst such organisms as bivalve shells, for the most part, sessile sightless animals; how ad-

vantages of form or habit work for the preservation and continuity of the differing species. Strengthening of hinge structure, increased solidity of the shell, lengthened siphonal tubes, stronger and more muscular feet, flattened shells to avoid impact of currents, roughened or spiculate surfaces for attachment to mud, rocks, sea-weed etc., attenuaton of form for insertion in crevices, development in byssus, gaping mouths, shoulders, elongation, curving backs, are features that might gain accentuation, and variously help their possessors to improved prospects in the life-race. And certainly many of these features are conspicuous in a review of the Devonian lamellibranchs, but specific distinctions based on a slightly more accurate form, a more nasute outline, a triangular form, a lengthened or shortened anterior or posterior margin, a variation in surface sculpture, a higher umbonal prominence, proximity or recession of beaks, while all doubtless justly weighed as specific marks, apparently have no conceivable reference to any particular advantage they bestow. They may be indeed steps in an advantageous march of modifications.

Schizodus shows a lengthening posterior edge, and both increase and decrease of the ridge, *Cimtaria* apparently becomes more curved dorsally with an explanate scooped out widening of its posterior end, *Mytilarca* becomes more acute umbonally, elongate, and compressed, the pterinoid genera show both increase and decrease of the wings, accentuation and softening of the surface sculpture, *Goniophora* becomes generally from the Schoharie, more expanded, with a less arcuate umbonal keel. *Pterinea flabella* found in the Upper Helderberg, but rare, is numerous in the Hamilton. It assumes a larger form with strong broad ribs in the Chemung, while around *Aviculopecten princeps* are grouped oscillations of related forms. *Panenka* and *Lunulicardium* were hardy genera surviving changed habitats.

The expansion of the Devonian lamellibranchiate fauna which seemed to begin in the Lower Helderberg was successively interrupted, and after each interruption widened its specific limits. Did the interruptions which expelled it to more restricted areas for development bring about the biological schock that caused the increase in species and a differentiation of new genera? It seems probable.

It is quite certain from the results of the Challenger expedition that the bothymetrical range of bivalves is most variable, as this compilation shows.

Genera	Depth in Fathoms	Genera	Depth in Fathoms
Martesia	49	Astarte	70-100
Teredo	1400	Crassatella	28-390
Gastrochaena	8	Cardita	10-60
Clavagella	7	Carditella	20-100
Solecutus	28	Mytilus	6-350
Saxicava	100-500	Myrina	1400
Mya	7	Crenella	140
Corbula	7-435	Idas	390
Anatina	18-28	Modiolarie	2-1675
Periploma	13	Modiola	15-800
Lyonsia	620-1950	Perna	10
Silenia	1950-2650	Lithodomus	8
Thracia	20-100	Dacrydium	100-390
Neaera	120-1950	Modiolarca	12-245
Poromya	155	Septifer	12
Pandora	7	Julia	40
Myodora	6-17	Avicula	8-30
Myochama	6	Malleus	3-12
Mactra	6-20	Pinna	38
Raeta	7	Arca	12-2000
Psammobia	6-70	Trigonia	2-38
Tellina	6-155	Glomus	390-1900
Donax	10	Pectunculus	7-1010
Semele	7-1000	Limopsis	28-1850
Ervilia	6-1000	Nucula	10-2050
Davila	20-150	Nuculina	15-20
Venus	3-1000	Leda	12-1675
Tapes	6-50	Sarepta	2385
Cytherea	7-70	Yoldia	28-345
Circe	2-435	Malletia	60-2550
Dosinia	6-25	Pecten	2-1375
Venerupis	70	Lima	2-2500
Petricola	8	Amussium	20-1675
Cardium	10-70	Spondylus	8-28
Callocardia	1000-2900	Plicatula	15-21
Chama	7-450	Anomia	50-350
Lucina	7-435	Ostrea	28
Tridacna	8		
Cryptodon	5-1900		
Diplodonta	6-150		
Kellia	28-38		
Montacuta	6-450		
Solemya	245		

If the Devonian lamellibranchs were expelled by the physical constants pertaining to the Marcellus and the Genessee or Portage, the expulsion of the Ammonoid fauna of the latter by the physical constants of the Hamilton and Chemung also excites comment. The Naples fauna, described by Dr. Clarke, is essentially cephalopdous, the Marcellus calcareous shales also contain a goniatitic fauna. There is an essential sim-

ilarity in the fauna of the Marcellus and Genessee despite specific or generic contrasts and the diversity of those in the latter may be regarded as the result of changes induced in the former during some period of sequestration and absence. Where the Marcellus fauna disappeared to it is impossible at present to determine, but its reappearance as the Genessee is not an unnatural supposition. The lithological resemblance of the Marcellus and Genessee is striking and would seem to represent similar or identical sediments. The fauna in each is marked by cephalopodous features and while the lamellibranchs of the Marcellus which remained within it from the Upper Helderberg seas are absent in the Genessee, the brachiopodous occupants of both are unmistakably related, and the ichthyic fauna of both suggest still further a biological affinity or descent.

If the specific changes evinced in the Chemung bivalves are traceable to the confinement of the Hamilton in limited zones of development and changed environment, upon continental elevation and its (the fauna's) recession to the margins of the deeper seas, then it is logical to reverse the deduction in direction and find in the expanded (?) Genessee fauna a growth and change produced by the retreat of the Marcellus to the interior edges of the continent upon the invasion of the deeper waters of the Hamilton.

In basins, bays, and inundated half land-locked emarginations, the Marcellus sea-life, and especially its ammonoid contents, developed in congested centers, and prepared the new efflux of species and genera later preserved in the Genessee shales.

These suggestions point to the seeming efficacy of circumscribed areas in the development of the species; that a certain amount of biological pressure brings about interactions, perhaps not always referable to struggle or natural selection, which modify form and create species. And yet aside from natural selection what influence in the proximity of species or individuals could possibly differentiate them? Is not such an expression as "biological pressure" both ambiguous and childish? It might more properly be assumed that an excess of nutrition, perfect thermal conditions, purity of water, eradication or absence of enemies brought about the highest var-

itetal liveliness, and produced vigorous "sports" whose very vigor was an assurance of continued heredity.

The next extreme illustration of a *biological crisis* in the palaeozoic rocks is found in the crinoid-swarming seas of the Lower Carboniferous. The whole series of palaeozoic rocks afford nowhere such an extraordinary development of crinoidal forms, and while crinoidal limestones are frequent from the Calciferous upward, and establish the strong prevalence of these organisms, the actual predominence of the Lower Carboniferous fauna excluding cystids and blastids *in species,* is quite unmistakable.

A compilation from Miller's catalogue affords this striking comparison.

	Genera.	*Species.*
Paleozoic to top of Devonian........	76	346
Lower Carboniferous	56	653

The same fecundity is shown in another way, by the greater number of genera marked by numerous species in the Lower Carboniferous over those excelling in species in the lower palaeozoics, while in none of the latter is there a comparable abundance to some of the more prolific genera of the Carboniferous seas. In the lower palaeozoics for instance, nine genera only have ten or more species assigned to them whereas in the Lower Carboniferous there are seventeen with *Actinocrinus* covering forty-seven species, *Barycrinus* twenty-three, *Batocrinus* fifty-two, *Cyathocrinus* thirty, *Dichocrinus* twenty-seven, *Dorycrinus* twenty-four, *Eretmocrinus*, twenty, *Eupachycrinus* thirteen, *Platycrinus* sixty-seven, *Poteriocrinus* sixty, *Scaphiocrinus* sixty-two, *Taxocrinus* sixteen, and *Zeocrinus* twenty-nine.

In the lower palaeozoics *Dendrocrinus* has twenty-seven, *Eucalyptocrinus* twenty, *Megistocrinus* twelve, *Poteriocrinus* fifteen.

The impression of great numbers in the crinoidal life in the Lower Carboniferous is not relieved by any considerations of a defective geological record in the lower palaeozoics. There is no reason for suspecting that the record has been less carefully kept in the latter period than in the former. We are therefore met by a distinct organic profusion in the palæocrinoids at that geological epoch, and must infer that a con-

junction of favorable circumstances and exuberant vitality in this phylum occurred at that time.

Dr. Carpenter in the "Voyage of the Challenger" has shown that while the stalked crinoids are partially abyssal they are not universally so, and if their abyssal habitat is to be interpreted as a retreat from shallower waters, we may be sure that the Lower Carboniferous seas were in no real sense abyssal. But it has been shown in the same work that the crinoids occur in groups, that if at any time they were continuously found over the sea that continuity is interrupted. There is a strong probability that in the Lower Carboniferous seas there was no geographical continuity of crinoidal life, but that a group of basins existed which were characterized each by its special faunal development, and had their origin somehow in the survival of those genera which existed in the early palæozoic, as *Agelacrinus, Calceocrinus, Cyathocrinus, Dorycrinus, Ichthyocrinus, Megistocrinus, Melocrinus, Platycrinus, Poteriocrinus, Synbathocrinus.*

And for this reason—the crinoids of the whole palæozoic are local, in distribution; they form segregated fossils. The expression of the group derived from their occurrence is sporadic, their habitat so to speak is concretionary. It can be accounted for by assuming that the character of the bottom is important in establishing their growth, that selection in this respect is decisive, and so, as the requisite foundations are limited, the crinoidal growth is limited and special.

In the Trenton, in New York, the *Caryocrinus* is found in small assemblages, and in the Cincinnatti beds *Iocrinus* and *Dendrocrinus* occur almost invariably in nests, groups, or bundles. In the Lower Helderberg *Mariacrinus* is also partial in its occurrence, and in the Waldron the *Eucalyptocrinus,* while more widely disseminated suggests colonies in its development. The *Megistocrinus* of the Upper Helderberg and Hamilton are uncommon, but when found are in bunches, and the large crinoidal stems in these formations seem crowded in localized areas.

The faunal basins we refer to in the Lower Carboniferous may have migrated, moved in and out, from the continent, up and down a coast line, but they became finally established in the Lower Carboniferous upon the most enduring basis,

and in broader zones, and there developed their numerous specific and generic variations.

But assuming a great age for this development, the expression of *suddenness* is not unwarranted in referring to them. There is certainly slender suggestion in the Devonian of such large and opulent supplies of crinoidal life. The "biological crisis" they present is not simply apparent. It is real.

The crinoidal basins of the Lower Carboniferous illustrate again what is remarkable in the trilobites of the Cambrian, and the lamellibranchs of the Devonian, a great development of species in limited geographical areas. It is not one species from one locality, another from a second, and so on, but a convergence of species at one locality or province.

Amongst the possible elements of encouragement for the luxurious growth of crinoids in the waters of the Lower Carboniferous seas, was the clearness of the latter, and their greater supply of lime than in the waters of our present seas. The withdrawal of the crinoids today into abyssal regions, while not universal, is a prevalent tendency, and may have some reference to the increased sedimentation along coast lines. It may also be inferred that this abyssal retreat is not congenial to a flourishing life of crinoids, and their disappearance from our modern seas is certain.

The elevation of the Lower Carboniferous continent was probably low, the drainage to the coasts slow or inconsiderable, and it seems reasonable to suppose that the areas of very clear water approached the shores closer than they do today, offering an advantageous nidus for the development of crinoidal life. The successful planting of the ova when the stalk commences to form (pentacrinoidal stage) may be attended with dangers to the life of the young crinoid, which only clear water and peculiar bottom conditions can avert. As to the more rapid and easy assimilation of lime, the weight of the suggestion that the Lower Carboniferous seas contained more lime than those of today may be very slight. Yet it is quite easy to see that there is a difference in the assimilating functions of a Neocrinoid with its leathery tegminal crown, and that of a Palæocrinoid with its strongly plated calcareous dome, and that difference may have been brought about by some gradual decrease in the lime contents of the ocean.

To be Continued.

PREGLACIAL EROSION IN THE COURSE OF THE NIAGARA GORGE, AND ITS RELATION TO ESTIMATES OF POSTGLACIAL TIME.

By WARREN UPHAM, St. Paul, Minn.

In the careful studies of the history of the Niagara river and gorge by Pohlman* and Gilbert,† as in the earlier observations of Lyell and Hall, the coincidence of the postglacial Niagara gorge with the preglacial St. David's channel at the Whirlpool is clearly recognized. The present river there has washed out the drift that filled the ancient channel and apparently reached to the bottom of the Whirlpool, about 130 feet above the sea. Thence the preglacial St. David's stream bed, beneath the drift, has probably this depth of 117 feet below the level of lake Ontario, or more, along its course past St. David's and onward to the deep central part of the lake Ontario basin.

The preglacial stream, as Pohlman has shown, drained the shallow Tonawanda valley, but not the area of lake Erie. At the Whirlpool this St. David's stream, according to Pohlman, plunged down in a cataract from the hard Medina sandstone bed, which is underlain and overlain by soft shales. Having at this place eroded a valley or ravine 400 feet deep and a quarter of a mile wide, the stream doubtless also had cut an important ravine, though of smaller size, along its higher course for a considerable distance before reaching the site of the Whirlpool. Dr. Pohlman supposes, with sufficient reasons, that the St. David's ravine reached along the part of the Niagara gorge occupied by the Whirlpool rapids, having a middle vertical fall over the Clinton limestone and terminating at an upper vertical fall over the Niagara limestone, beyond which, in its approach from the south, the stream was only a little lower than the adjoining country.

Some of the latest contributions to the geologic literature of Niagara, by Taylor, Hitchcock, and Gilbert, assign to the St. David's channel an interglacial age, and regard it as the

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Proc. Am. Ass. Adv. Sci., vol. xxxii, 1883, p. 202; vol. xxxv, 1886, pp. 221, 222. *Trans. Am. Inst. Mining Engineers*, vol. xvii, pp. 322-338, with maps and sections, Oct., 1888.

†Sixth Annual Report of the Commissioners of the State Reservation of Niagara, for the year 1889, pp. 61-84, with 8 plates (maps and sections); also in the Smithsonian Report for 1890. Monographs of the National Geographic Society, vol. i, pp. 203-236, with 21 figures in the text, Sept., 1895.

course of a great river, an interglacial Niagara, which was allowed the time requisite for the erosion of a gorge about three and a half miles long, from the escarpment near St. David's to the south side of the Whirlpool, but was then interrupted by the accumulation of ice again deeply enveloping all this region. This explanation, however, seems to me inadmissible, because the St. David's channel expands northward in that distance to the width of more than a mile before it intersects the escarpment. If it had been cut by a great interglacial cataract, its width would be nearly uniform, like the present river gorge. A comparatively small preglacial stream, on the contrary, working slowly through many million years, would have the older part of its valley thus widened by the very long subaerial decay and retreat of its rock cliffs on each side. So great lateral erosion cannot be ascribed to glaciation, which was light upon this area of confluent ice currents from the northeast and northwest, with consequent deep drift deposition.

Immediately after the melting of this southern part of the ice-sheet and the withdrawal of the ice-dammed lake Warren, the Niagara river began to erode its gorge, and it has continued in this work, under varying conditions, to the present time. It found a lower passage along the course of the gorge to Lewiston than in the course of the preglacial channel, deeply drift-covered, between the Whirlpool and St. David's. From my renewed examination of these areas this year, with the aid of the contoured map distributed by the U. S. Geological Survey at the Pan-American Exposition, of the latest studies by Gilbert,* published on the reverse side of the map, and the valuable "Guide to the Geology and Paleontology of Niagara Falls and Vicinity," prepared by Prof. A. W. Grabau, summarizing the conclusions of all preceding geologists, for the many visitors who come to this Exposition and to Niagara during the present year, I have to add to these and to my own former studies another factor in the Niagara history, namely, that the erosion of the gorge below the Whirlpool had been partly accomplished by a small preglacial stream which flowed along nearly the entire length of that earliest part of the gorge, after draining at its head, farther east, probably nearly the same area as the present Fish creek. Joining the St. David's channel at the Whirlpool,

*Reprinted in the AM. GEOLOGIST, vol. xxvii, pp. 375-377, June, 1901.

this eastern tributary undoubtedly had cut a deep ravine, with falls and cascades, along its last mile or more. At the east end of the Foster flats and farther up stream, the preglacial Fish creek had only a very shallow valley, slightly hollowing but not trenching the bed rocks.

Under this view we see readily how the Niagara river withdrew its waters from the low cataract at the Foster flats. On reaching the head of the preglacial ravine in the gradual recession of the falls, the main current, which passed on the southeast side of the flats, speedily eroded a deeper channel, far below its former bed above that cataract, because the drift filling the old ravine was easily swept away. Along a distance of nearly two miles, adjoining the Foster flats and northeasterly, the river flowed afterwards in powerful rapids, eroding this part of the gorge into the rock strata to its present depth; and the greater depth, with slow and smooth current, for a half mile between the flats and the Whirlpool may be due to such deep erosion by the preglacial stream there, its ravine having been cut down nearly to the bottom of the St. David's channel before coming to their junction.

Evidently the preglacial brook that coincided somewhat nearly with the present Fish creek could not have passed northward through the Niagara escarpment in the course of the river gorge. The crest of the escarpment there is higher than the land stretching south and southwest to the Whirlpool. The gorge has no widening, such as is a most remarkable feature of the old channel at St. David's, where it approaches and cuts the escarpment; nor does it show evidence of much greater age there, as geologists count time, than along any other part, even near the present cataract. Prof. G. F. Wright has proved, instead, that the oldest part of the gorge, at and near the escarpment, can have endured the inevitable weathering of its cliffs no longer than 10,000 years, and that indeed its age, which is also the entire age of the Niagara river and falls, mav be a considerably shorter period.*

Above the Whirlpool it seems very clear to my mind that the gorge erosion was much aided by the preglacial St. David's stream for the distance of one mile occupied by the

*"New Method of Estimating the Age of Niagara Falls," *Popular Science Monthly*, vol. lv, pp. 145-154, with six figures in the text, June, 1899.

great rapids. Here the greater part of the depth and width of the gorge had probably been already eroded before the Ice age, being then filled with drift, which the postglacial river easily removed as soon as its gorge toward Lewiston was sufficiently deepened. No powerful falls have there cut a deep channel, and the river consequently has a constricted and very rapid course. Above the old St. David's ravine, however, a massive waterfall has operated along the latest distance of nearly two miles of the gorge, giving to the river there its great depth.

The action of a high waterfall, with great volume of water, precipitated over a hard stratum of which large blocks give way and fall because they are gradually undermined, as in the Horseshoe or Canadian falls of Niagara, is well compared by McGee to the deep wearing of potholes. The fallen blocks are moved under the powerful impact of the high cataract and wear a deep channel, attaining near the foot of the present falls the depth of almost 200 feet under the river level. Such cataract action of deep channel wearing may be also supposed to have produced the great depth (96 feet) of the Niagara river at the mouth of the gorge; but I think that this is better attributed to the usual process of stream cutting at the time of depressed level of this part of lake Ontario, which is otherwise known by its lower inclined beaches extending here under the lake.

Among the conditions which might cause the Niagara river to vary from its present size, only one would produce a great and long continued diminution of the river, so giving for a large part of its history only very slow erosion of the gorge. This hypothetical factor in our problem, which has been assumed by Gilbert, Spencer, Taylor, and Hitchcock, to considerably prolong the time of the gorge erosion, is the diversion of the outflow from the basins of the three lakes above lake Erie, then confluent and forming the glacial lake Algonquin, to forsake its present course and pass eastward from Georgian bay, at first by the way of lake Simcoe and the Trent river to lake Ontario, and later by lake Nipissing and the Mattawa river to the Ottawa.

But differential elevation of the land from its Late Glacial or Champlain depression took place here, as on the area

of lake Agassiz, as soon as the land was unburdened by the glacial retreat. This northward uplift was in progress while yet the ice barrier remained farther north and northeast, holding in succession the glacial lakes Warren and Algonquin, besides several earlier and smaller glacial lakes which became merged in lake Warren, on the upper part of the St. Lawrence basin. In the areas of lake Agassiz and of the Laurentian lakes alike, the uplift was nearly completed during the existence of the glacial lakes, as is known by the almost undisturbed horizontality of the latest and lowest glacial lake beaches. Finally lake Algonquin, by the northeastward land elevation, became divided into its successors, lakes Huron, Michigan, and Superior.

Instead of the hypothesis of long continued eastward outflow from lake Algonquin, my studies convince me that the Trent and Mattawa outlets were occupied successively during only a brief time, or, more probably, that these outlets were obstructed by the receding ice-front until after the land there had risen from its Champlain depression to such altitude that the St. Clair and Detroit rivers continued to be constantly the outlet from the upper lake basins, sending their waters to the Niagara river and falls during all their history. Lakes Algonquin and Iroquois were contemporaneous, and the Ontario basin inclosing lake Iroquois was at the same time uplifted toward the northeast, with inclination of its earlier shorelines, and with gradual rise of the lake on the land westward because its outlet at Rome, N. Y., was raised much more than the western part of the basin. While these two glacial lakes were undergoing such changes, a lobe of the mainly retreating but wavering ice-sheet lingered on the highlands north of lake Ontario; and twice its moderate readvance was recorded by deposits of till intercalated with the stratified beds of a lacustrine delta in the extensive section of Scarboro Heights near Toronto. The uplift of the Iroquois basin as well as that of the Algonquin basin, is thus shown to have been far advanced and nearly completed during the continuance of their ice barriers.

Latest, the glacial lake St. Lawrence, held by the final blockade of the waning ice-sheet on the St. Lawrence valley below Montreal, extended into the lake Ontario basin with a

depth of about 150 feet above the Thousand Islands, but with its water level beneath the present surface of the west part of this lake. In like manner with the earlier lake Iroquois, the progressing northeastward uplift caused the level of the lake St. Lawrence and afterward of lake Ontario to rise upon the land in the southwest part of the Ontario basin. It was during these late stages of the lacustrine history of this region that the deep channel of the Niagara river at the mouth of its gorge was eroded, the channel being subsequently partially refilled with water by the continuance of the northeastward land elevation. The river from Lewiston north to its mouth has a depth of 100 to 200 feet, which indicates almost as much rise of this part of lake Ontario, for no high waterfall existed to erode the very deep channel there.

The vast country which had been ice-covered and depressed under the weight of the thick continental ice-sheet was gradually uplifted, and to a greater hight at the north than at the south, during the removal of the ice burden. While lakes Agassiz and Warren still existed the northern parts of their areas were raised, in comparison with their southern outlets, 300 to 400 feet or more. It is also found, by the present inclinations and relationship of the successively formed shorelines of these and the other associated glacial lakes, that this epeirogenic movement proceeded as a permanent wave of land elevation from the periphery of the old ice-sheet inward to its central area.

Accurate maps of the crest line of the falls were made by Hall in 1842, by the U. S. Lake Survey in 1875, by Woodward in 1886, and by Kibbe in 1890. It is thus ascertained that in the forty-eight years following the first survey the lengthening of the gorge, by the recession of the central part of the Horseshoe fall, was 270 feet, the average rate being about five and a half feet yearly. But the central curve or apex of the cataract is worn back much faster than its sides, because the river has its maximum depth of fully twenty feet at its center and there makes a plunge of not merely the 160 feet from the verge to the surface of the water at the foot of the fall, but of nearly 200 feet lower to the bottom of the river, working thus most effectively to undermine the horizontal rock strata and break down the thick limestone at the top.

The entire extent of the Horseshoe fall is found by these surveys to be worn away at an average rate of about two feet yearly; but during the four years from 1886 to 1890 the average annual rate of erosion for the whole was five feet. Along the more shallow American fall, northeast of Goat island, the mean yearly erosion is about two-thirds of a foot, but from 1886 to 1890 it averaged one and two-thirds feet. The energy of this part of the Niagara cataract is not sufficient to remove its huge fallen blocks of limestone, on which the water strikes along all the base of the precipice.

Only the center of the Horseshoe fall plunges deeply into the river beneath, and its concentrated and intensified erosion tends at present to lengthen the gorge beyond its normal rate, which appears probably to be about three or four feet yearly. With such average erosion, the recession of the falls and prolongation of the gorge would amount to one mile in about 1,500 years; and the action of the great cataract along the two miles of deep water south of the railway bridges would have begun about a thousand years before the Christian era. The entire erosion of the six and a half miles of gorge between Lewiston and the present falls would require about 10,000 years, excepting that this period would be diminished probably about a third, to 7,000 years, more or less, by the preglacial erosion of the St. David's stream and its northeastern tributary.

In 1841 Sir Charles Lyell estimated the rate of lengthening of the gorge to be about a foot yearly, and its age therefore about 35,000 years. Gilbert, at the Buffalo meeting of the American Association for the Advancement of Science in 1886, comparing the exact surveys, estimated the recent rate of recession of the falls to be about five feet yearly, giving, if this were the average for the whole gorge, about 7,000 years for its erosion. Pohlman, in 1888, considered the recent recession to be at the rate of a mile in 2,000 years; but the whole period, as he first showed, was much diminished on account of the preglacial erosion. Later, in consideration of a supposed loss of the outflow of the upper great lakes, leaving to the Niagara river, during a very long time, only a small part of its former and its present volume of water, the age of the river and

gorge has been computed by Spencer as 32,000 years;* by Taylor, about 50,000 years;† and by Hitchcock, about 19,000 years.‡ Wright, from a different and independent computation, based on the subaerial erosion and widening of the gorge in its most ancient northern part, concludes, as before noted, that its age is no more than 10,000 years.

But there are, as this discussion has also before noted, ample reasons for distrusting the arguments and computations of Spencer and others concerning eastward outlets from the upper lakes, subtracting their flow from the Niagara river, which, as I believe, are untenable, or, at the most had only a very short existence. Omitting that element of the problem as insignificant, we have approximately 7,000 years, according to the diverse but concurrent computations, for the probable time occupied in the erosion of the gorge.

Not satisfied with thus rejecting the hypothesis of long and great subtraction from the water supply of Niagara, I wish to direct attention to a very important cause of great increase of size of the river and falls at the beginning of the gorge erosion. The discharge of the river during the last 1,000 years may be approximately represented by 1,200 or 1,500 feet of water covering all the upper St. Lawrence drainage basin above these falls. This average water supply I believe to have been doubled or trebled during the first 1,000 years of the river history by the added flow derived from the final melting of the ice-sheet, mostly 3,000 to 5,000 feet or more in depth, upon a very large region stretching from lakes Huron and Superior far north and northwest. For some part of this time the Niagara river probably received the outflow from the basin of the glacial lake Agassiz, that is, the vast central tract of Canada between James bay and the Rocky mountains.§ Within its first 1,000 years, therefore, the more powerful Niagara may have accomplished about half of its gorge erosion between Lewiston and the Whirlpool. When the river was reduced to its present size, after its tributary ice melt-

*AM. GEOLOGIST, vol. xiv, pp. 289-301, Nov., 1894; *Am. Jour. Sci.*, third series, vol. xlviii, pp. 455-472, Dec., 1894; Eleventh Annual Report of the Commissioners of the State Reservation at Niagara, for the year 1894, pp. 99-117, with maps, sections, and views from photographs.

†*Bulletin, Geol. Soc. Am.*, vol. ix, pp. 59-84, with two maps, Jan., 1898.

‡*Am. Antiquarian*, vol. xxiii, pp. 1-24, with maps and views, Jan. and Feb., 1901.

§"The Glacial Lake Agassiz," Monograph xxv, *U. S. Geol. Survey*, 1895, pp. 227-244.

ing ceased, 2,000 years were probably adequate for the completion of the gorge to the Whirlpool, the work having been greatly lessened by preglacial erosion. Similarly, on account of the old St. David's ravine, 1,000 years, or less, would suffice for the erosion along the Whirlpool rapids. Afterward, under the present conditions of gorge lengthening, 3,000 years were needed for the last two miles, next to the present falls. The whole history would thus comprise about 7,000 years.

This measure, which (not to be too exact in figures depending on the many varying conditions of the Niagara history) we may place in round numbers as between 5,000 and 10,000 years, is at the same time the duration of the period since the end of the Ice age, or, speaking more definitely, since the retreat of the continental glacier from the northern United States and Canada. It may be accepted with confidence, for it agrees with the estimates and computations independently made for the same period by Prof. N. H. Winchell, from the recession of the falls of St. Anthony; by Dr. Andrews, and recently also by Leverett, from the shore erosion of lake Michigan and the accumulation of sand at its south end; by Wright, from the filling of depressions among kames and eskers, and from erosion by streams tributary to lake Erie; and by Prof. B. K. Emerson, from postglacial deposition in the valley of the Connecticut river. In Europe, likewise, numerous estimates of the lapse of time since the Glacial period, as collated by Hansen, are found to be comprised between the limits of 5,000 and 12,000 years, being thus well harmonious with the measure given us by Niagara falls.

In accordance with the ratios of the relative duration of preceding geologic periods and eras, having now found the approximate measure of the latest term in the series, namely, this Postglacial period, as about 7,000 years, we may well estimate the whole Quaternary era, including the Ice age, as about twenty times longer, giving to this era some 150,000 years. The Tertiary era, with erosion of the stupendous Colorado cañon and baseleveling of the plains between the Red River of the North and the Rocky mountains, appears by the changes of its marine molluscan faunas to have been vastly longer, having comprised probably three to five million years; and the very long preceding eras since life began on the earth

may have included, as estimated by Dana, Walcott, and others, about one hundred or two hundred million years.

If a much longer time than the 7,000 years estimated in this paper should be admitted for the duration of the Niagara river and the Postglacial period, as Spencer and Taylor suppose, all the terms of this geologic series making up the age of the earth must be proportionallv multiplied five-fold or sevenfold. The whole would then pass far beyond the maximum limit which seems to have been reliably determined by the researches of geology, astronomy, and phvsics.

NOTE ON CERTAIN COPPER MINERALS.*

By ALEXANDER N. WINCHELL, Butte, Montana.

Chalcopyrite has been noted more than once as an accidental product in metallurgical operations. Thus, Hausmann† described it as resulting from imperfect roasting of copper bearing ore at the works in Goslar and in Ocker. The mineral was here found in crystals exceeding five millimetres in largest diameter, twinned and striated: the crystals were of a fine black color, and a little altered on the surface.

Plattner‡ noted similar crystals in a crack in the bed of a reverberatory furnace at Mulden near Freiberg. These crystals contained, according to analysis, a slight excess of iron, and small amounts of foreign metals.

So far as known to the writer bornite has never been described as an accidental furnace product, nor as produced artifically by sublimation. Its reproduction has been accomplished only by fusion, or by the action of thermal springs upon bronze.

It is intended here to describe an occurrence of chalcopyrite and bornite at the smelter of the Butte & Boston Consolidated Mining Co., at Butte, Montana. The minerals form slowly, attaining their maximum thickness of about four inches in the course of six months to a year. They form in the Allen-

*Read at the Denver meeting of the American Association for the Advancement of Science, August, 1901.

† HAUSMANN:—*Goett. gelehrt. Nachr.*, 1852, No. 2, p. 177, Ref. from Encyc. Chimique. BOURGEOIS:—Reproduction artificielle des mineraux, p. 45.

‡ FUCHS:—*Die kunst. darg. Min.*, p. 62, ref. from same source.

O'Harra calciner along the rails in the bed of the furnace. In fact, they not only form beneath the flanges of the rails, but also slowly replace the rails themselves. This replacement continues to such an extent that finally, when the rails are taken out, they have only a thin upper surface layer of iron; all the rest has been transformed into chalcopyrite and bornite, with the exception of that portion of the rails completely embedded in the brick bed of the furnace. Furthermore, the replacement is so gradual that it is impossible to distinguish any exact line of demarcation between the remaining iron of the rail and the mineral sulphides.

An examination of these sulphides shows that, while they are somewhat impure from mechanically admixed quartz and perhaps some other foreign matter, they exhibit the true characters of chalcopyrite coated in places with films of bornite, occasionally of appreciable thickness. Thus, the former mineral has an uneven fracture, a hardness less than 4, a brass yellow color, and a greenish streak. The specific gravity is considerablv decreased by foreign matter present, being only about 3.8. The mineral occurs both finely and coarsely crystalline, and these varieties pass abruptly into each other. In a small lenticular cavity several crystals were found, which attained only about one-fourth of a millimeter as a maximum diameter. They were nearly all tarnished by a coating of bornite, but a few retain a brass yellow color. They present the tetahedral aspect predominatingly; some seem to be mere triangular tablets. Twinning occurs, apparently parallel to (111), and striations are abundant.

The massive mineral was subjected to partial analysis. The copper was determined by means of the potassium cyanide method, the iron being filtered off and weighed after the titration was nearly completed. The powdered mineral was treated with boiling nitric acid for about half an hour, and it is therefore possible that small amounts of silica and alumina are included in the iron percentages; the sulphur was determined by the ordinary barium sulphate method. The analysis was carried out in the mineralogical laboratory of the Montana State School of Mines on material presented to the school by Mr. John Gillie, superintendent of the Butte & Boston Consolidated Mining Co.

	I.	Ia.	II.	IIa.	III.	IV.	V.
Cu	25.63	28.95	25 15	28.00	34.5	15.8	27.5
Fe	34.51	38.97	35.79	39.86	30.5	39.4	38.8
S	28.40	32.08	28.85	32.14	35.0	29.0	30.0
SiO_2	8.62	………	9.20	………	…….	9.2	3.4
Total	97.16	100.00	98.99	100.00	100.0	93.4	99.8

I. Chalcopyrite from Allen-O'Harra calciner of the Butte & Bost[on] smelter, Butte, Montana. No zinc nor nickel. A. N. Winchel[l] analyst.

Ia. Same recalculated, omitting SiO_2.

II. Calcopyrite from Allen-O'Harra calciner of the Butte & Bost[on] smelter, Butte, Montana. No zinc nor nickel. A. N. Winche[ll] analyst.

IIa. Same recalculated, omitting SiO_2.

III. Theoretical composition of chalcopyrite.

IV. Chalcopyrite from Allen O'Hara calciner, Butte & Boston smelt[er], Butte, Montana. 10 oz. Ag. Mr. Steele, assayer for the C[o.] analyst.

V. Chalcopyrite from Castellina Marit., Italy. C. Bechi, analy[st]. Amer. Jour. Sc., 1852, xiv, p. 62.

The similarity between the analyses of the artificial cha[lco]pyrite and the natural mineral analyzed by Bechi is stri[king] … to be noted further that the crystals analyzed … [illegible]

[illegible] sufficient amount to perm[it] … [illegible] by the presence … The blue and red … these colors are also … [illegible]

… have been formed … the temperature of … the present … [illegible] formed by … the same … [illegible]

	I.	Ia.	II.	IIa.	III.	IV.	V.
Cu............	25.63	28.95	25.15	28.00	34.5	15.8	27.54
Fe............	34.51	38.97	35.79	39.86	30.5	39.4	38.80
S..............	28.40	32.08	28.85	32.14	35.0	29.0	30.07
SiO_2.........	8.62	....	9.20	....	....	9.2	3.45
Total........	97.16	100.00	98.99	100.00	100.0	93.4	99.86

I. Chalcopyrite from Allen-O'Harra calciner of the Butte & Bostcn smelter, Butte, Montana. No zinc nor nickel. A. N. Winchell, analyst.

Ia. Same recalculated, omitting SiO_2.

II. Calcopyrite from Allen-O'Harra calciner of the Butte & Boston smelter, Butte, Montana. No zinc nor nickel. A. N. Winchell, analyst.

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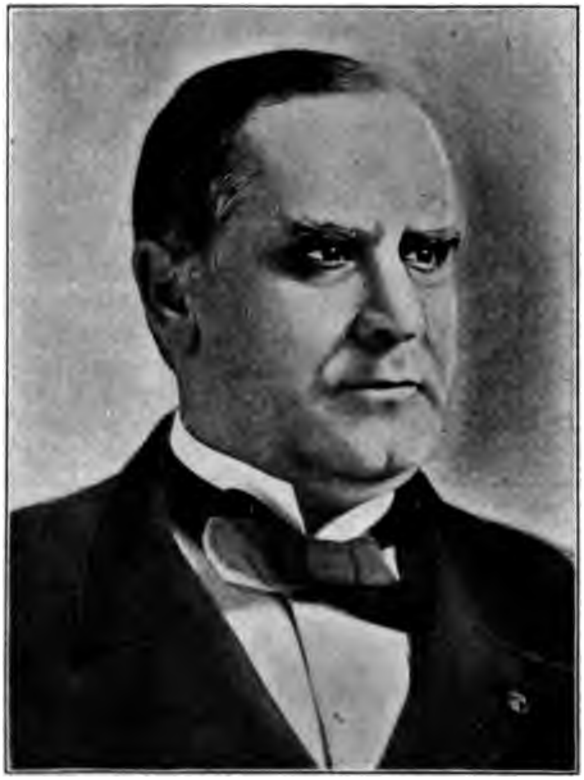
V. Chalcopyrite from Castellina Maret., Italy. C. Bechi, analyst. *Amer. Jour. Sc.*, 1852, xiv, p. 61.

The similarity between the analyses of the artificial chalcopyrite and the natural mineral analyzed by Bechi is striking. It is to be noted, further, that the crystals analyzed by Plattner contained a slight excess of iron, as does the mineral here described.

The bornite does not occur in sufficient amount to permit of analysis, but its identity is established by the presence of the irridescent colors peculiar to it. The blue and red colors on different faces are abundant; and these colors are also modified by the yellow of the chalcopyrite.

Both the chalcopyrite and the bornite have been formed by sublimation, and not by fusion, since the temperature of the furnace never rises high enough to fuse the ores present.

Summarizing, we have here another example of chalcopyrite as a furnace product: in this case it is formed by sublimation; and, as it forms, it replaces and destroys the iron rails of the calciner. Further, we have the formation of bornite in small amounts by sublimation under the same conditions which lead to the formation of chalcopyrite in much larger amounts.



William McKinley,
Late President of the United States of America.

EDITORIAL COMMENT.

EDWARD WALLER CLAYPOLE.

Prof. E. W. Claypole, one of the charter members of the Geological Publishing Company, died at Long Beach, California, Aug. 17. He had been complaining of a "nervous trouble," as he termed it, for some time. It had settled in his left hand and his right foot, and hampered him so that he could not get about as he had been used to do. In a recent letter to the writer he remarked that he had had the most harassing year of his life, resulting from the sickness of Mrs. Claypole and his own disability. His trouble culminated in a sudden rheumatic attack at the heart whch brought on unconsciousness which continued until his death, two days later, at sixty-six years of age.

Born in England he adopted America, but with a lingering love for his boyhood's hearthstone, which caused him to revert affectionately to the associations and institutions of his native land. He was well known in England as a geologist prior to his coming to the United States, and several of his scientific contributions written since have also been published in England.

His was a retiring, scientific temper and turn of mind and manner. He disliked the heat of any dispute, and rarely mixed in any fray. His even tenor of mind was displayed in the character of all hs papers. He seemed to think the power of truth was so great that it required only a plain and simple statement to make it invincible, however its acceptance might be delayed by error and misrepresentation. In a quiet way however, he was unswerving from what he considered right, and would return to the same, when opposed, from different points of view, though never with direct contradiction of his opponent. In that he always displayed the highest type of mental civility.

His services to geological science were numerous and highly important, and will be noted more in detail in a future number of the GEOLEGIST, to which he was a frequent contributor.

The scope of his studies, and of his writings, was broad. As a scientist he belonged to the old school, to which belonged most of the geologists of fifty years ago. He did not content himself with specialization in any line, but participated in physics, paleontology, glacial geology, prehistoric anthropology, and in all general geology, biology and botany.

He was educated at the University of London from which he received the degrees of B. A. and D. S. He was professor of Natural Science at Antioch College, Ohio, 1873 to 1881; paleontologist to the Second Geological Survey of Pennsylvania, professor of Natural Science at Buchtel college, Akron, Ohio, from 1883 to the time of his removal to Pasadena (1898) where he was professor of biology and geology in the Throop Polytechnic Institute till the time of his death He was a fellow of the Geological Societies of London, Edinburgh and America, and of the American Association for the Advancement of Science. He was greatly beloved and revered by his pupils and by all others with whom he came into contact. In the highest sense he was one of humanity's natural noblemen.

N. H. W.

THE ORIGIN OF AUSTRALIAN IRON ORES.

A recent publication by the Department of Mines and Agriculture of New South Wales* contains a valuable contribution to the origin of iron ores. Recognizing various conditions and origins of iron ore, as given by the author, the writer refers here specially to the aluminous iron ores and bauxites of Wingello. It is important that like some others Mr. Jacquet associates bauxite and hematite in a common discussion and assigns to them an identical origin, viz. a change from igneous rock, generally basalt. No such associated origin has been ascribed to the bauxite deposits of the United States. The intimate connection of the pisolitic iron ore with basalt in New South Wales appears to have been noted by C. S. Wilkinson in 1872, and later by Mr. T. W. E. David. Mr. David says: "This formation has a superficial area of eleven square miles, five hundred and seventy-seven acres, and a thickness of from a few feet to

* *Memiors of the Geological Survey of New South Wales. Geology No. 2.* The Iron Ore Deposits of New South Wales. J. B. JAQUET, Sydney, 1901.

forty feet. These beds at the surface consist of red dusty soil, passing downwards into red, yellow or gray tuffs and compact pisolitic ironstone, which in turn graduates into rotten spongy basalt." * * * As specimens of the rock vary considerably in structure and composition the term laterite must be taken to have rather a wide application. While some of the specimens are clearly tuffs, others show little trace of eruptive origin, and may be described as earthy pisolitic ironstone, more allied to a sedimentary formation than a volcanic. * * * The probable explanation of these facts appears to be that the greater part of the laterite is an altered basalt tuff belonging to the earlier basalt eruptions of the Eocene period." In 1899 Mr. Jacquet reported that the pisolitic ironstone near Wingello contains free alumina, and is a variety of bauxite. Since that date samples have been chemically tested from many allied deposits, and the results show that ferruginous bauxite is distributed over a considerable area of the colony. This ore is of Tertiary age, as evinced by fossil-bearing strata associated with it. These strata are sometimes overlain by basalt.

The ore is composed of rounded grains of concentric structure, and varying in size from two millimeters in diameter to eight centimeters. Two analyses showed respectively alumina thirty-four and thirty-two per cent. and iron (Fe_2O_3) twenty-nine and forty-four per cent; also 4.45 and 4.70 per cent of titanic acid. The former analysis was of an oxidized sample, and the latter, in each case, of an unaltered primary ore. "The second analysis seems to indicate that the primary ore consists essentially of a mixture of ilmenite and ferruginous bauxite."

The author concludes that not only this but probably many other deposits of bauxite and aluminous ores elsewhere in the world have been derived from alteration of basalt; although in some cases not from alteration *in situ* but from the distributive action of water in shallow lakes or rivers in Tertiary time,

Mr. Jacquet calls attention to the somewhat similar iron ores of the Clealum river in Washington which have been described by Mr. J. P. Kimball,* and by Messrs. Smith and Willis, and which contain free alumina and may perhaps be designated ferruginous bauxites. Messrs. Smith and Willis† state: "The Clealum ore resembles in a general way some of the more ferruginous bauxite ores, and, as has been seen,

* American Geologist, 1898, xxi, pp. 161-163.
† *Trans. Am. Inst. Min. Eng.*, February, 1900.

it also occurs with the same relations to a basic rock that the German bauxites show to basalt."

In another chapter the author describes "basaltic iron ore," *i. e.* such that is derived undoubtedly during the process of weathering from basalt. This he considers an additional link in the evidence which goes to prove that aluminous iron ores may have a residual origin from basalt.

The writer considers the report and conclusions of Mr. Jacquet as contributory evidence of the truth of his hypothesis of the derivation of the Mesabi iron ore which is also sometimes distinctly pisolitic, from basic volcanic sand gathered on the beach of the Tacomic ocean and accumulated in greater thicknesses in the adjacent shallow waters. N. H. W.

THE ANTIQUITY OF THE RACES OF MANKIND.

In view of the latest discussions bearing on this question, by Howorth in the August number of the *Geological Magazine,* and by McGee and others at the Denver meeting of the American Association, it seems timely to note here some of the geologic evidences of the great antiquity of man, and to consider the origin of his principal races, commonly called white, yellow, red, and black.

Among the numerous localities in the northern United States where traces of man's presence during the closing part of the Ice age have been found, is one in Gaines, Orleans county, N. Y., about fifty miles east-northeast from Niagara Falls. A prehistoric hearth was here encountered in digging a well, at the depth of fifteen to eighteen feet below the surface, being at the base of the beach ridge of gravel and sand which marks the highest southern shore of the glacial lake Iroquois, about 175 feet above lake Ontario (G. K. Gilbert, in the *American Anthropologist,* vol. ii, pp. 173,174, April, 1889). Charred sticks, with ashes, and three boulders laid to inclose the fireplace, there attested man's abode, or a transient hunting expedition, at the time when the front of the receding ice-sheet yet rested on the adjacent part of Canada close north of Toronto, and on the Adirondacks and the St. Lawrence valley, turning the outflow of lake Iroquois to the Mohawk and Hudson rivers. The Niagara had just begun to cut its gorge; from

which the subsequent lapse of time is computed to have been about 7,000 years.

Evidences of man in somewhat earlier stages of the general decline of the Ice age are found in the Trenton gravels of the Delaware valley, in similar valley deposits of Ohio, and in the modified drift of the Mississippi valley at Little Falls, Minnesota. Much older geologic testimony of primitive man has been obtained in Idaho and California, carrying the record back to a period probably preceding the Ice age, but within the Quaternary era. It is certainly our duty, however, as urged by Holmes, to accept such testimony only when it is very clear and reliable.

Geologic archæology in Europe rests on a firmer basis of ample observations, indubitably demonstrating man's existence there before the culmination of the Glacial period, and indeed, I think, before its beginning. From my examination of the implement-bearing gravel deposits of the Somme valley in northern France, where the proofs of man's great geologic antiquity were first recognized and published, I conclude that Paleolithic men began their occupation of that country before the epoch of great elevation of the lands which became glaciated, probably contemporaneously, in both Europe and North America (AMERICAN GEOLOGIST, vol. xxii, pp. 350-363, Dec., 1898). This conclusion, affirming the vast antiquity of mankind, but admitting many differences of views as to the history of the Quaternary era and formation of the drift, is believed by Howorth to be shared by the majority of European geologists.

The origin of the great races of mankind, namely, the Caucasian or white race, the Ethiopic or black race, the Mongolic or yellow race, and the American or red race, seems probably to have been the result of many thousands of years under the influences of climate, food, and other conditions of life, in the several great continental regions inhabited by these races, to which mankind had previously become dispersed. The beginning of the human epoch, when our species gained such development of body and mind as to deserve its generic and specific name, *Homo sapiens*, we cannot well designate more clearly than to say that it far antedated the close of the Ice age. It was undoubtedly several times more ancient than the western Aryan migrations, which, by their relations to the waning Eu-

ropean ice-sheet, appear to have occurred some 5,000 to 10,000 years ago. According to my studies as a glacialist, it seems to me that Flinders Petrie has given as satisfactory estimates as can be made with our present knowledge, in his recent suggestions assigning 100,000 years as the probable duration since Paleolithic man appeared in the Somme valley, and 10,000 years since Neolithic man came into western Europe. Eolithic man, known by his very rude stone implements in stream deposits which are preserved on high plateaus in southern England, belonged doubtless to a time considerably earlier than 100,000 years ago; so that we may perhaps allot twice that period for the existence of man and the development of his principal races.

All mankind, however, constitute only a single species. A requisite condition of distinctness separating species is the inability to produce hybrid offspring, or, when such offspring is possible to nearly allied species, it is incapable of reproduction. Judged by this essential part of the definition of every zoologic or botanic species, the whole human family is specifically a zoologic unit. All its races and varieties are freely fertile with each other. However different in color, stature, features, mental attainment, or all other qualities which distinguish races and nations, they blend together. Such intermingling, mostly of the black and yellow races, has apparently been the origin of the Malay, Australian, and Polynesian peoples. In America, on the contrary, no considerable foreign intermixture seems to have occurred since the very early time when this continent was first peopled. The immigration came probably from northeastern Asia, across Bering strait, and perhaps in part also, at nearly the same time, from Europe, over a land connection by the Faeroe islands, Iceland, and Greenland.

An objection to such migrations of primitive man during the Glacial period may be based on the ice-covered condition of North America at that time, wholly enveloped by an ice-sheet upon its northern half, northward from the Ohio, Missouri, and Columbia rivers, excepting the greater part of Alaska. If the preglacial and early Glacial altitude of the continent had been the same as now, this objection would be valid, and we should be obliged to refer these ancient migrations

wholly to a time before the accumulation of the North American ice-sheet, which reached both east and west beyond the present coast lines. But it has been ascertained that this northern part of our continent was then elevated 3,000 to 5,000 feet higher than now. During the epoch of ice accumulation and culmination, its boundaries probably failed to reach generally to the coast line of that time. Along the sea border, where food supplies such as savages rely upon are most easily obtained, preglacial and Glacial man may have freely advanced on a land margin skirting the inland ice, as along the present borders of Greenland. It was only in the Champlain epoch, closing the Glacial period, that the ice-burdened lands sank to their present altitude or lower, bringing the edges of the ice-sheet beneath the encroaching sea.

The many divergent branches of the American peoples and their remarkable progress toward civilization in Mexico, Central America, and Peru, before the discovery by Columbus, indicate for this division of mankind probably almost as great antiquity as in the eastern hemisphere. Although we are unable to define the date, in thousands of years of antiquity, when the American race came into its heritage, we may paradoxically say that it came here before it had been differentiated from the primordial stock of mankind so as to be racially distinct.

Processes of change, whether of progress or of regression and sometimes extinction, are now taking place and are modifying species and races perhaps as fast as during any former period in the history of our globe. We see allied varieties or races of plants and animals, living intermingled in the same district, or more frequently in different but adjoining regions, or sometimes quite separated geographically, which are not yet sufficiently distinct to rank as separate species, but which seem surely destined to diverge more, until their increasing difference and decreasing affinity shall give them that more distant relationship. The parent stock and the diverging branches are all the while represented by multitudes of individuals. Divergent species and races, therefore, have come into their present strongly contrasted characters from preceding ancestry which was a unity in its specific character, but which resembled any vigorous species of the present time in comprising a vast number of individuals occupying a somewhat extensive geographic area.

The Creator, working through long ages by these processes of descent with modification, which we call evolution, has developed the great races of mankind from some single older and much different ancestral species of less intelligence. Anthropology, the science of the development of man and his races and tribes, agrees thus with the words of the inspired apostle Paul, in his address to the Athenians, teaching them of God who "made of one blood all nations of men to dwell on all the face of the earth." W. U.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The New Basis of Geography. By J. Q. REDWAY. The Macmillan Co. Pp. 229. Price $1.00.

This book, which is written primarily as a manual for teachers of geography, will be of interest to the wider circle of students of geography. The new geography, to quote the preface, is "the mutual relation of geographic environment to political history on the one hand and economic development on the other." The first half of the book deals with this subject of geographic environment. After considering the influence of environment on man's historical development, the writer takes up various incidental influences of topography on life and concludes this part of the book with a very interesting chapter on the effects of topography and climate on the economic history of the United States. In a book of this compass the treatment must be suggestive and elementary, rather than exhaustive.

The second half of the book is of more strictly pedagogical interest, and deals with aims and methods of geographic teaching in the elementary and secondary schools. Many of the suggestions will prove helpful to teachers of physical geography and geology in secondary schools.

It is a pleasure to get hold of a work in which the writer has something to say, knows what it is, and then goes on to say it in a clear, incisive and attractive manner, so much of our geological and geographical writing is done in other lines. L. G. W.

Paleozoic Faunas of Northern Arkansas; by H. S. WILLIAMS. (Arkansas Geol. Sur., Ann. Rept. 1892, pp. 268-362, 1901.)

Probably no region of its size has had so much geological investigation carried on within its borders, and at the same time had so little accomplished regarding the geological age of the various formations, as the Ozark highlands. What has been needed most has been exact paleontological data. It is therefore an exceptional pleasure to see the recently issued chapter on the Paleozoic Faunas of Northern Arkansas.

Professor Willams' notes are the outcome of much labor in the field by many individuals, extending over more than a decade.

Concerning the general problem presented, professor Williams says: "On account of the apparent conflict between the interpretation of the stratigraphy made by the field observers and the interpretation suggested by my study of the fossils, I went to Arkansas in August, 1890, and traversed the ground with Dr. Branner, confirming the fact of sudden and great change in the paleontological horizons, in several places where the lithological characters of the rocks and the stratigraphy little and often obscure evidence of facts. Although our examination was rapid and very few additional fossils were accumulated, the great importance of the Devonian interval, as it may be called, was clearly established. The course traversed was from Batesville westward, across country, to Eureka Springs. The best expression of the details of the interval were seen at St. Joe, where, without apparent unconformity of strata, the Silurian limestone is separated by a few feet of green shale and nodular sandstone, called Sylamore sandstone, from the Carboniferous limestone."

The geological formations are assigned ages as follows:

Carboniferous.	Genevieve or Boston group. Batesville sandstone. Spring Creek black shales. Cherty beds (Boone chert). Carrollton limestone. St. Joe marble. Eureka shale (typical).
Devonian.	Sylamore sandstone. Eureka shale (in part).
Silurian.	St. Clair limestone.
Ordovician.	Polk Bayou limestone. Izard limestone. Saccharoidal sandstone. Calciferous, or Magnesian, limestone.

The faunas of the several formations are then indicated and briefly discussed. Among the noteworthy features brought out, none is of greater significance than the determination of the dual character of the great limestone which the Arkansas field geologists had long called the St. Clair limestone. One part carries a typical Ordovician fauna, while the other contains Silurian fossils. The distinction is especially important from an economic standpoint. The manganese deposits of the state are found on the horizon which separates the two parts of this limestone, whenever the two are present in the same section. "Whenever the manganese is present it is always above or at the top of the Polk Bayou limestone of the section. The evidence is conclusive, therefore, that the erosion, causing the interval, was after the deposit of the Polk Bayou limestone, and the evidence of the few fossils in the Cason shale indicates that the manganese-

containing deposit was made at an age closely corresponding to the Clinton of the New York sections, and was incident to the deepening seas which soon after received the limestone formation of the St. Clair (Niagara) epoch.

The Devonian of the Ozark region has always been a puzzle to geologists. Professor Williams' observations go a long ways in solving some of the most perplexing phases. "In numerous places in north Arkansas the evidences of an unconformity separating the Silurian from the overlying Carboniferous, are very clear. In some cases there is no rock-material separating these two grand terranes. In other cases there are greenish shales, or coarse sandstones, with polished grains and rounded nodules of black shale; and in the western section the interval is occupied, in part, by a black shale, the Eureka shale of the Washington County report." The fauna in the fine shales which succeed the black shales is correlated with that of the Louisiana or lithographic limestone, and "is thus as late as the Kinderhook stage of the Eocarboniferous."

The interpretation of the facts is "that the typical interval-materials, the green shale and the Sylamore sandstone, were deposited after the period of the formation of the typical black shales which, along the borders of the Ozark uplift, was terminated, or actually driven outward, by the elevation of that region; that these particular deposits mark the stage of sinking again of the land and the resultant erosion which introduced the Carboniferous formations for this region; that the time was at the very close of the Devonian and beginning of the Carboniferous eras. I conclude that the explanation of the varying age and nature of these deposits is due to the sections having been taken at places at lower or higher position on the gradually sinking land and expressing the overlap of the successively more recent deposits. Further study of the whole problem of the deposits filling the Devonian interval in the South has led to the conclusion that, however much erosion of the underlying Silurian formation took place, the sediments of black mud forming the shale, did not begin till after the beginning of the Devonian era. The age of the beginning of the new sedimentation being determined by the first fossils above the abrupt change, the unconformity may not be indicated by conspicuous modification of the plane of sedimentation. We should less expect real unconformity in the central part of the continental mass, as in the Mississippi valley region than on the borders where the folding and faulting has been chiefly concentrated."

There is one statement concerning the Carboniferous which deserves more than passing notice. It relates to the Spring Creek division, which may be the equivalent in part of the Fayetteville shale of the western part of the state. "It is of interest to note the connection between the sharp and decided change of fauna and the change in the lithology of the rocks. The passage, beginning with the red marble, is from argillaceous shales, through calcareous and often crystallized, to cherty limestone, becoming more and more cherty at

the top. Then comes a sudden change; black shales, and black sheets of limestone, with silicious sand mixed with them; sometimes beds of sandstone; but the order is various and different in separate sections a few miles apart.

"It was in this black shale and limestone, with more or less sandstone, that the new fauna arrived; in the present case, a remarkable fauna for the locality. It included species which have never been seen before in the Mississippi valley, but are known in Nevada. It includes species which were never known before to occur so late in the series, but are common types in the preceding Devonian. The fauna points to some change by which communication was made with distant localities in the, then, sea basin." On the whole the Paleozoic faunas of northern Arkansas may be said to be the most notable contribution to our knowledge of the Ozarks that has ever been made. C. R. K.

What is an Echinoderm? by F. A. BATHER. (Jour. London Coll. Sci. Soc. Vol. VIII, pp. 21-23, London, 1901.)

An article which deserves more than passing notice by paleontologists is the admirable summary of our knowledge relating to the echinoderms, which Dr. Bather gave a short time ago in a lecture delivered before the City of London College Science Society. Coming from one who is not only a zoologist but who has had wide experience with fossil forms of life, the subject is viewed from the broadest possible position.

After considering briefly the characters by which an echinoderm may be distinguished from all other organisms, the three principal theories as to the origin and evolution of this group are summed up. These three theories are the ones which have had most influence upon morphologists. They are called the "Calycinal," the "Pentactæa," and the "Pelmatozoic" theories. The last of these seems now to be winning acceptance, but the other two cannot be dismissed without some words.

The first of these theories, the Calycinal of Loven, Carpenter and Sladen, "asserts that certain skeletal elements, with a definite arrangement, form the ground-plan of all echinoderms, which, therefore, are all descended from an ancestor with such composition of its skeleton. The elements in question are the circlets of plates that are present in the theca or calyx of a typical crinoid, namely, the five orals around the mouth, the five radials from which the arms spring, the five basals below the radials, the five infrabasals occasionally found between the basals and the stem, and finally a plate of more dubious nature—the dorsocentral."

The "Pentactæa theory" of Semon crystallized the views of those who held that "the holothurians were the most primitive among echinoderms, and the family Synaptidæ the most primitive among holothurians. Early in the life history of Synapta occurs a stage with five tentacles around the mouth, and into these pass canals from the water-ring, the radials canals to the body-wall making a subsequent, and only temporary appearance. Semon called this stage the Pentactula, and

supposed that in its early history the class had passed through a similar stage, which he called the Pentactæa and regarded as the ancestor of all echinoderms."

The third theory seems to have broader foundations than either of the others. "Any theory of the origin and evolution of the echinoderms has to explain those features in the structure and life-history of living echinoderms to which attention has been called: it has to find [illegible] a for the varied structures of extinct forms, more particularly the ancient crystids; and it has to connect the echinoderms with some anecedent group, whose structure shall not be echinodermal, but comparable with that of some more simple animals now known to us. * * * Opinion trends towards the belief that the most important of these steps was a fixed stage through which the group passed at an early period of its race-history, and the theory that this is the explanation of the peculiarities of echinoderm structure may be called the 'Pelmatozoic theory.'" C. R. K.

Iowa Geological Survey, Volume XI. Administrative Reports. SAMUEL CALVIN, State Geologist; A. G. LEONARD, Assistant State Geologist. Des Moines, 1901; pp. 519, with 12 plates, 9 geological maps of counties, and 43 figures in the text.

This volume contains a statement of the progress of the survey during the year 1900, and of its chief directions of special investigations, by Prof. Calvin; a chapter on the mineral production of the state in that year, by Dr. S. W. Beyer; and detailed reports on the geology of Louisa and Pottawattamie counties, by Prof. J. A. Udden; of Marion county, by B. L. Miller; of Cedar county, by Prof. William H. Norton; of Page county, by Prof. Calvin; and of Clay and O'Brien counties, by Prof. Thomas H. MacBride. About half of the state has now been geologically mapped and described, including more than forty counties variously grouped throughout its whole area.

It is announced that Dr. Beyer is preparing a monograph on the clays of Iowa; that Prof. Norton is preparing a further report on artesian wells, supplementing his previous work; and that a monograph on the grasses of Iowa, by Prof. L. H. Pammel, is in press, to be issued as one of the publicatons of this survey. During the present year investigations of the present soils of the state were expected to be taken up by Mr. Milton Whitney, chief of the Soil Division of the United States Department of Agriculture.

The production of coal in Iowa last year amounted to $6,977,466; of clay industries, $2,395,488; and of stone, gypsum, lead and zinc, and iron ore, together about $1,000,000. W. U.

Structure and relations of Uintacrinus; by **FRANK SPRINGER.** (Mem. Mus. Comp. Zool., Vol. XXV, pp. 1-90, 8 pls., Cambridge, 1901.)

Ever since its discovery, the Cretaceous crinoid Uintacrinus has **been of great interest to morphologists** and paleontologists. So much **has been** [illegible] **this remarkable type** of crinoid that it would **seem t**[illegible]**ording** remained to be told. Yet now

comes a new and ponderous monograph containing a mine of suggestive information, exhaustively considered and superbly illustrated.

The great feature of general interest is the bearing of the discussion on crinoid classification. At a single stroke all existing classifications are not only thrown into confusion, but the last prop is taken from under certain of those schemes of systematic arrangement which are claimed to rest securely on phylogenetic foundations.

Uintacrinus has long been regarded as one of the rarities in crinoid collections. Its recorded occurrences were few. Mr. Bather, however, after wide travel in Europe, found the form to be really widely and abundantly distributed. In Kansas, great slabs containing hundreds of beautifully preserved specimens were recently obtained.

To the morphologist, Mr. Springer's studies are a revelation in many ways. Some features which he brings out are unique. The remarkable information relating to the structure of the base is particularly noteworthy. The main distinguishing feature of the two great subclasses of Dicyclica and Monocyclica are here found in one and the same species.

In order to appreciate fully the importance of the present discovery, reference must be made to the recent text-books on zoology and paleontology. "There is no doubt that the occurrence of these two forms of base in this genus is a most extraordinary fact. Nothing like it has ever been observed before among the crinoids, to my knowledge," says Mr. Springer. "Wachsmuth and Springer held the presence or absence of infrabasals to be a good family character, except in case of the Reteocrinidæ, in which dicyclic and monocyclic genera—otherwise markedly similar—were included by us. It was the difficulty presented by these genera that prevented us from attributing to this character a higher value and wider significance. Mr. Bather, on the other hand, considered the difference in the two forms of base as sufficient to separate the Crinoidea Inadunata into two suborders. He has lately in the chapters on the Echinodermata in Part III of Ray Lankester's treatise on zoology, elaborated a scheme of classification, embracing the whole of the Pelmatozoa, on phylogenetic principles, in which he subdivides the class Crinoidea into two sub-classes: Monocyclia and Dicyclica.

"The validity of such a division of the Inadunata was first combated and denied in the monograph of the Crinoidea Camerata, upon grounds which it is not necessary to restate here. There was undoubtedly much plausibility in the suggestion of these two divisions, more as to the Inadunata than to the Camerata. What made it especially attractive was the fact that it was based upon differences in the primitive elements of the crinoid organization, representing phylogenetically different early stages of the only crinoid whose embryology we know. And the argument which was considered by its author to be conclusive, was the assumed fact that there was no such thing as a transition from one form of base to the other. What, then, is the significance of the present discovery in relation to this question? It presents a difficulty far more formidable than the case of the Reteorcrinidæ.

"For those are Lower Silurian types.—among the earliest known crinoids; and it is quite possible to suppose, if the crinoids diverged into two lines of development on this character, that they represent stages somewhat near the point of such divergence. If the two forms of base represented in Uintacrinus had been found in specimens otherwise separable they would, under Mr. Bather's arrangement, have been unquestionably referred to different genera, families, orders, and subclasses. Considering the apparent identity of these forms in every other point of structure, coupled with their mode of occurrence and association, I do not see how any such separation can possibly be made in this case. We therefore have apparently to deal with a case of individual variation, as to this supposed primitive character, within the limits of a species. That is to say, in this species, living in the same locality, having the same environment, floating in the same mass, certain individuals matured to represent one stage of larval development, *i. e.* with infrabasals; and others in another stage, *i. e.* with basals only.

"In short, there are the two supposed distinct types, Monocyclica and Dicyclica, occurring in both young and adult of one and the same species. It will not do to say that the species is dicyclic, but in a certain individuals the infrabasals are not developed, or hidden by the centrale, or have disappeared by atrophy. If this were so the centrale ought to be interradial in both cases; whereas, as already shown, its orientation is reversed from one to the other, precisely as in typical monocyclic and dicyclic forms.

"At all events, we have in Uintacrinus perfect proof that in some cases the characters of a monocyclic or dicyclic base are subordinate to others, and do not mark the line of descent."

The nine beautiful plates of figures give the best graphic representation of Uintacrinus that has ever appeared. C. R. K.

Coal Fields around Tse Chou, China; by NOAH FIELDS DRAKE. (Trans. American Inst. Min. Eng., Vol. XXX, pp. 261-277, 1901.)

On account of the recent exciting changes on the checker-board of the far east, the coal supplies of China have an unusual interest. Every addition to our knowledge of these coal fields since the explorations of Baron von Richthofen, over three decades ago, is now scanned with avidity. Dr. Drake's contribution comes at an opportune time.

The coal fields of Shansi lie about four hundred miles southwest of Peking, near the great Yellow river. The long journey was taken mainly on slow river-boats, and the somewhat limited time at the command of the author, allowed only work to be done in the district around Tsè Chou. Until very recently the hostile attitude of the Chinese government and people towards foreigners and their enterprises, has kept the coal-fields from being developed.

The rock formations are roughly divided into three great terranes. There is a basal limestone formation, the *Kohlenkalk* of Richthofen, aggregating 2,000 feet or more in thickness; a median formation composed of shales, coals, sandstones, and a flint-bearing limestone bed,

aggregating about 500 feet in thickness; and an upper terrane made up of shales, and sandstones of about 1,000 feet in thickness.

The workable coal lies in one bed 250 feet above the flint-bearing limestone. "In the Tsé Chou region the average thickness of the main or workable coal-bed is probably not less than twenty-two to twenty-three feet. At the mine about one and a half miles west of Hsi Tayang, the coal is worked through a shaft 329 feet deep. I had no opportunity to measure the full thickness of the bed, or to examine more than the part that is being mined. Only the lower ten to twelve feet of the coal is being mined. I was told by the Chinese miners that the full thickness of the bed is thirty feet (Chinese), which is equivalent to about thirty-six feet (English)." There is no waste material in the coal bed in any of the mines. If twenty-two feet is taken as the average thickness and 1.5 as the average specific gravity of the coal, there are about 3,000,000,000 metric tons of coal within the 150 square miles, which is about the amount of the coal area included in the map. It must be remembered that this area is only a little of the ragged edge of the great coal fields of Shansi. Most of Shansi has been found underlaid by large coal fields, and the coal area of this province is greater than that of Pennsylvania.

All the coal of the Tsé Chou region is anthracite. The present style of working the mines and transporting the coal presents a striking contrast to what might be done were modern methods used. The great thickness and the almost horizontal position of this coal bed make it practicable to run long lines of railroad tunnels through the bed and load the cars in the mines for distant transportation. C. R. K.

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PERSONAL AND SCIENTIFIC NEWS.

DR. E. R. BUCKLEY of the Wisconsin Geological Survey, has been elected State Geologist of Missouri.

PROF. R. D. SALISBURY of the University of Chicago, has been in Montana, in charge of several geological parties from that university.

DR. LOOMIS of Amherst, has been spending the summer with the American Museum parties in South Dakota, Wyoming and Colorado, as volunteer assistant.

MAJOR A. W. VOGDES has been transferred from Fort Hamilton, to the Artillery District of San Diego. His address is San Diego Barracks, California.

DR. THOMAS L. WATSON, of the Geological Survey of Georgia, has been appointed to the chair of geology and botany in Denison University, at Granville, Ohio.

DR. W. D. MATTHEW of the American Museum of Natural History, has been spending the summer in Wyoming and Colorado, collecting vertebrate fossils for the museum.

DR. F. H. KNOWLTON recently made large collections of fossil plants in the John Day basin, Oregon. He was accompanied by Prof. J. C. Merriam of the University of California.

MR. J. E. SPURR, who is in the employ of the Sultan of Turkey, has begun examination of Macedonia and Albania. His residence is on the banks of the Bosphorus, his address being Constantinople, *via* Open English mail.

THE OFFICERS OF SECTION E, elected at the Denver meeting of the Association for the Advancement of Science, are O. A. Derby, Sao Paulo, Brazil, vice-president; and F. P. Gulliver, Southboro, Mass., secretary. Prof. Asaph Hall, Cambridge, Mass., was elected president of the Association.

THE EARLIEST TRACES OF MAN. Sir Henry Howorth, author of "The Glacial Nightmare," considers paleolithic man was preglacial, and neolithic man postglacial. In a work, soon to be issued by him, he condenses a vast mass of evidence justifying that classification. He has an interesting article on this topic in the *Geological Magazine* for August.

GEOLOGY OF THE SOUTH AFRICAN REPUBLIC. The late official geologist, M. Molengraaf, has prepared and issued what may be considered his final summary report. It is printed in the bulletin of the Geological Society of France, fourth series, vol. I., No. 1. June, 1901. This survey, interrupted and terminated by the unfortunate war of the last two years, is thus not entirely lost. The report extends through seventy-nine pages, and has a general geological map.

AMERICAN METEORITES DESCRIBED. In the Vienna *Annalen K. K. Natur-historischen Hofmuseums*, band 15, Heft 3-4, 1900, professor Cohen publishes his "Meteoreisen-Sudien XI." This includes new descriptions of the following American meteorites: Illinois Gulch, Deer Lodge Co., Montana; Deep Springs farm, Rockingham county, North Carolina; Hammond, St. Croix county, Wisconsin; Cacaria, Durango, Mexico; Mezquital, Durango, Mexico; Murphy, Cherokee county, North Carolina; St. Francis county, Missouri; Crosby Creek, Cooke county, Tennessee; Cañon Diablo, Crater mountain, Arizona; Merceditas, Chanaral, Chili; Kendall county, San Antonia, Texas; Minas Geraes, Brazil; Mount Joy, Adams county, Penn., (schreibersite).

THE SUMMER SCIENTIFIC MEETINGS AT DENVER, COL., Aug. 27-31, were notable, not only for their geographic location, i. e. in the eastern foothills of the Rocky mountains, but for their success as scientific meetings. The geologists who attended were greatly satisfied with the carefully arranged programs of geological excursions, and with the character of the papers that were presented. Prof. C. R. Van Hise, vice-president of Sec. E of the American Association for the Advancement of Science, gave an evening popular address on the methods of deposit of ores by underground waters. He questioned the possibility of the origin of ore-deposits by upward flowing waters, and urged instead that such deposits originate, in the first instance, from downward moving waters, thus differing from Posepny. He thus reached the conclusion, borne out by facts cited, that after passing below the surface oxidized zone of mineral veins, the richest deposits are in the upper portion,

and that instead of increasing in value with depth all veins, in primal conditions, show diminishing values at great depths, until they are finally abandoned.

Prof. T. C. Chamberlain gave a memorable discussion of the nebular hypothesis of La Place, summing up some of the results of his investigations continued through several years. From different points of view he finds that the nebular hypothesis is untenable when subjected to the test of modern means and methods of science. He showed that the *spiral nebula* is a normal condition of primordial matter, much more common in the heavens than has been supposed. The abandonment of the nebular theory would require the reconstruction of much astronomical as well as geological theory as to the origin of the earth.

The geologists present are very much indebted to the local geologists of Colorado for the success of the meetings. Of these should be mentioned Profs. Geo. L. Cannon, H. B. Patton, F. W. Cragin, Arthur Lakes, George H. Stone.

GEOGOLICAL EXCURSION IN COLORADO.

Preceding the Denver meeting of the American Association for the Advancement of Science, a ten days' excursion was taken through Colorado. The excursion was under the auspices of Section E. of the A. A. A. S., and with the co-operation of the Geological Society of America. Leaving Denver on the morning of August 16th and returning to that point on the morning of August 26th, the party visited a number of localities important as centers of geological and mining interests. Mr. C. R. Van Hise was the leader of the excursion, and he was ably assisted by Mr. S. F. Emmons on ore deposits and general geology, and by Mr. T. C. Chamberlin on glacial and physiographic geology.

The first stop was at Canyon City where a visit was made, under the guidance of Mr. J. B. Hatcher, to the famous dinosaur quarries. The Lower Silurian beds, in which the earliest known vertebrate remains have been found, were examined, and some of the typical "hogbacks" were studied. From Canyon City the party walked through the Royal gorge of the Arkansas which is cut in a complex of Pre-Cambrian gneisses and granites.

At Aspen visits were made to some of the prominent mines and the main features of the district—one which has been much faulted—were noted.

The latter part of the trip was spent in the San Juan district, stops being made at Ouray, Telluride and Silverton. This is a very mountainous district, where erosion has cut deeply into the sedimentary rocks, which vary in age from Pre-Cambrian to Tertiary and which are capped by great

thicknesses of volcanic fragmentals and flows. Visits were made to a number of the important mines, trips were taken across some of the high passes in the mountains, and there was abundant opportunity to study the effects of the glaciers which once occupied the high mountain valleys.

From Silverton to Durango the route lay along the Animas Canyon which cuts Pre-Cambrian gneisses, granites and quartzytes, and lower down this valley a good section of the Paleozoic and Mesozoic rocks was seen.

Every one on the excursion was highly pleased and it was a marked success. The success was in considerable part due to the courtesies extended by the citizens of the places visited, —especially Aspen, Ouray and Telluride. Among these citizens should be mentioned Mr. F. T. Freeland of Aspen, and Messrs. Collins, E. J. Fields and H. C. Lay of Telluride, and Mr. T. L. Walsh, whose guests the excursionists were while at Ouray.

The following gentlemen participated in the excursion, a few of them not being present the whole time:

R. M. Bagg, Jr., Colorado Springs, Colo.; H. F. Bain, Idaho Springs, Colo.; E. H. Barbour, Lincoln, Nebraska; J. C. Branner, Stanford University, Calif.; Samuel Calvin, Iowa City, Iowa; G. L. Cannon, Denver, Colo.; R. T. Chamberlin, Chicago, Ill.; T. C. Chamberlin, Chicago, Ill.; C. R. Eastman, Cambridge, Mass.; S. F. Emmons, Washington, D. C.; H. L. Fairchild, Rochester, N. Y.; J. W. Finch, Victor, Colo.; U. S. Grant, Evanston, Ill.; J. C. Hersey, Leadville, Colo.; V. G. Hills, Cripple Creek, Colo.; J. D. Irving, Washington, D. C.; W. S. Kelley, Leadville, Colo.; Arthur Lakes, Denver, Colo.; J. R. Macfarlane, Pittsburg, Pa.; J. D. Newson, Stanford University, Calif.; H. B. Patton, Golden, Colo.; A. H. Purdee, Fayetteville, Ark.; W. N. Smith, Madison, Wis.; C. R. Van Hise, Madison, Wis.; A. N. Winchell, Butte, Montana.

THE UNIVERSITY OF TEXAS MINERAL SURVEY. A survey of parts of Texas, bearing the above title, was authorized by an act of the Legislature approved by the governor, March 28, 1901. It provides for a "mineral survey of the lands belonging to the public schools, university, and asylum, or of the State, and to make appropriation therefor, and to provide a penalty for unlawfully disclosing information obtained by such survey," etc. By Section 1 the management of the survey is placed under the control of the Board of Regents of the University of Texas. Section 2 requires that "said Board shall employ * * * persons skilled, who have had at least five years' experience in the science of mineralogy, geology and chemistry, who shall conduct the survey." Section 3 relates to the publication annually, for free distribution of the information collected by the survey

as it progresses, and provides, as a penalty, a fine "not exceeding one thousand dollars or two years in jail" for divulging information concerning the public school, university, asylum or State lands in advance of publication. Section 4 provides "for assays, analyses and other scientific examinations of specimens of mineral substances found in the state, and for the collection and distribution of statistics relating to the mineral production of the state." For assays, etc. "uniform and reasonable charges shall be fixed." By Section 5 provision is made for instruction in the University "in practical, economic and field geology and mineralogy." Section 6 authorizes the removal of the specimens, books, and equipment of the former Geological Survey of Texas (Dumble survey) to the University. These are loaned to the Board of Regents until such time as the state may otherwise desire to use them. Section 7 is as follows: "For the purpose of carrying out the provisions of this act, the sum of ten thousand dollars per annum for two years, or so much thereof as may be necessary, is hereby appropriated out of the general revenue of the state; provided that said mineral survey of the state shall be completed within two years."

The survey was organized by the Regents of the University on May 4, 1901, at which time the following appointments were made:

William Battle Phillips, Ph. D., Professor of Field and Economic Geology and Mineralogy, Director.

Henry Winston Harper, Ph. D., M. D., Associate Professor of Chemistry, Chemist.

Benj. F. Hill, M. S., M. A., Assistant Geologist.

Omerod H. Palm, B. S., and S. H. Worrell, Assistant Chemists.

The first publication of the survey, issued under the date of July, 1901, but delayed until August, bears the title "Texas Petroleum." It consists of 102 pages, two maps, and numerous illustrations, and is a history of the oil development in the state up to the date of publication.

President Prather, of the University, under the date of July 15, makes the following announcement: "It is expected that material will be collected for a similar bulletin upon the gold, silver, copper, lead and zinc prospects and mines west of the Pecos river by about the first of next year. Following this will probably be issued a bulletin upon the extent and utilization of Texas deposits of cement rock, sulphur, asphalt rock, clay products, building stones, etc."

The work thus far done is extremely creditable to the survey. Dr. Phillips is a man of great energy, who, notwithstanding the limited appropriation, will undoubtedly accomplish much that will prove of lasting benefit to the state.

Sincerely
Theodore G. White

THE AMERICAN GEOLOGIST,
VOL. XXVIII. PLATE XXIII.

THE

AMERICAN GEOLOGIST.

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THEODORE GREELY WHITE.

BY HEINRICH RIES, Ithaca, N. Y.

PORTRAIT.

Theodore Greely White died at his residence in New York city on July 7th, in the twenty-ninth year of his age. His death was sudden and unexpected, and will be much regretted by all geologists who were acquainted with him and his work.

Dr. White was born August 6th, 1872. He received his early education in New York city, and even while still a schoolboy showed the deepest interest in natural science and through his contagious enthusiasm interested many others of his age in the same subject. He entered the Columbia University school of mines in 1890, and during his college vacations devoted much of his time to botanical work, making a detailed study of the flora of Mt. Desert, Me. He received the degree of Ph. B. from Columbia in 1894, his graduation thesis being "The Geology of Willsboro and Essex townships," N. Y. This piece of work was really the beginning of a far larger investigation, which he took up for his doctorate, viz. the study of the Ordovician in the Lake Champlain valley.

Subsequent to his graduation, Dr. White remained at Columbia as a post-graduate student in geology, taking his M. A. degree in 1895 and his Ph.D. in 1898. In 1895 and 1896 he served as lecturer for the Department of Public Instruction, New York. From 1896 to 1900 he was assistant in the Department of Physics, Columbia University, and in this work showed marked success as a teacher.

Dr. White's work on the Ordovician of the Lake Champlain valley, had consumed much of his time for several years,

and the manuscript was fortunately in such form that it can be sent to press, for it represents a splendid piece of work, and one at which he had labored almost unceasingly. He also had nearly completed a paper on the petrography of the rocks around Mt. Desert, Me.

Always an active church member, he decided in 1900 to give almost his entire time to philanthropic work among boys and young men. He was especially interested in boy's clubs, and with his own ample means was engaged in establishing a boy's club known as the Gordon House at the time of his death. Indeed it was his untiring devotion to this cause which so taxed his strength that when taken ill he had no vitality left with which to combat the disease.

Dr. White was a man of great energy and perseverance, and never left a piece of work until he felt that everything had been done towards its completion which was possible, and it is most sad that his life should have been cut off when he was entering upon a most promising career.

He was a fellow of the Geological Society of America, the New York Academy of Science, Torrey Botanical Club, American Association for the Advancement of Science, New York Mineralogical Club, and other organizations. For two years prior to his death he served as secretary of the geological section of the New York Academy of Science.

He frequently contributed to various periodicals and a list of his geological papers is given below:

Publications of Dr. Theo. G. White.

The geology of Willsboro and Essex townships, Essex county, N. Y. Trans. N. Y. Acad. Sci., Vol. XIII, pp. 214-233, pl. 6 and 7.

An account of the Summer's Work in Geology on Lake Champlain (with G. van Ingen). Trans. N. Y. Acad. Sci., Vol. XV, pp. 19-23.

The Upper Ordovician Faunas in the Lake Champlain Valley. Bull. Geol. Soc. Amer., Vol. X, pp. 452-462.

The Original Trenton Rocks. Amer. Jour. Sci. (3), Vol. II, 1896, pp. 430-432.

The Faunas of the Upper Ordovician Strata at Trenton Falls, Oneida Co., N. Y. Trans. N. Y. Acad. Sci., Vol. XV, pp. 71-96, pl. II-V.

Report on the Relations of the Ordovician and Eo-Silurian Rocks in portions of Herkimer, Oneida and Lewis Counties. Appendix A. Ann. Rep. N. Y. State Museum, 1894, p. 28.

A Contribution to the Petrography of the Boston Basin. Proc. Bost. Soc. Nat. Hist., Vol. XXVIII, No. 6, pp. 117-157.

NEW ZEALAND IN THE ICE AGE.*

By C. H. HITCHCOCK. LL. D.

PLATES XXIV-XXVI.

It was my good fortune two or three years since to spend a month in New Zealand, travelling the entire length of the two principal islands. During this period I noted the peculiar characteristics of the glacial phenomena; and will briefly describe them as they appeared to one familiar with the ice-markings of North America. The New Zealand geologists have been diligent in their study of these vestiges, with considerable divergence in their opinions. I append a list† of the papers written by them which I have consulted, including explorations in the Southern Alps among the living glaciers, The conclusions to be stated later are my own.

New Zealand consists mainly of two large islands, the one southwest of the other in direct line, both together being about one thousand miles long. It is only the southern island that possesses active glaciers and important evidence of ancient ice-action. It has an area of 55,000 square miles, the two together amounting to 100,000. The trend is northeast and southwest; width on the average 140 miles; length about 500, lies between latitudes 41° 30′ and 46° 40′, longitudes 166° 30′ and 174° 30′ west of Greenwich. A range of high mountains is situated nearer the west than the east coast, reaching the maximum of 12,349 feet in Mt. Cook. Only two other peaks exceed 11,000 feet, and there are thirteen more than 10,000 feet high in the Southern Alps. The predominant winds are from the northwest and there is a greater precipitation of moisture on the northwest coast, the extreme annual amounts of rain fall being 126 inches at Hokitika on the northwest and twenty-five inches at Christ Church on the southern side.

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* Read before the American Association for the Advancement of Science at the New York meeting.

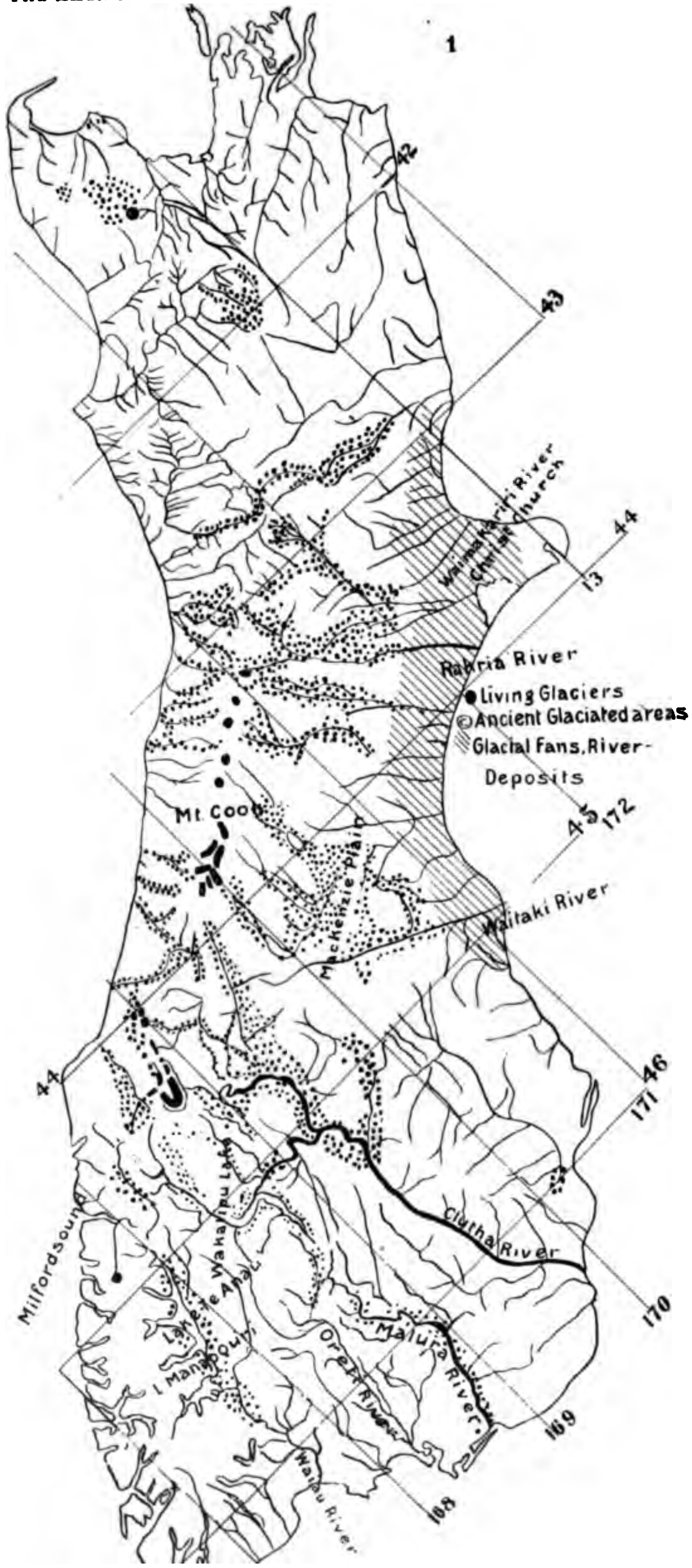
† New Zealand, its Physical Geography, Geology and Natural History, etc. by F. VON HOCHSTETTER, 1867, English edition.
Geology of Canterbury and Westland. By JULIUS HAAST, 1879.
With Axe and Rope in the New Zealand Alps. By G. E. MANNERING, 1891.
Camp Life in Fiordland. By WILLIAM MCHUTCHESON, 1892.
Official Reports of the Department of Lands, 1893-1897. By S. PERCY SMITH, General Surveyor.
Pioneer work in the Alps of New Zealand. By A. P. HARPER, 1896.
Climbs in the New Zealand Alps. By E. A. FITZGERALD, 1896.
Report of the Research Committee appointed to collect evidence as to glacial action in Australasia in Tertiary or Post Tertiary time. CAPTAIN F. W. HUTTON, reporter for New Zealand. From Proc. Australasian Association for the Advancement of Science.

The terminal faces of the glaciers now in motion vary with their position. The most northern are near latitude 41° at Mt. Arthur descend to 3,600 and 3,000 feet on the eastern slopes, and to 3,000 and 2,700 feet on the western slopes. In the Alps the Tannan glacier terminates at the altitude of 2,500 feet; the Francis Joseph and Fox glaciers on the west of the slope terminate at 950 and 734 respectively. Farther south, as upon Mt. Earnslaw, the glaciers terminate much higher up and diminish in rise. There may be glaciers above latitude 45° unknown to mankind because of the lack of exploration.

THE FIORD REGION.

In the earlier periods glaciers must have abounded in this elevated southwest portion of the island, because of the existence there now of numerous fiords. In the New Zealand summer (January) steamers visit these fiords or sounds for the benefit of tourists. There are thirteen of these interesting chasms on the southwest coast stretched over two degrees of latitude, the most romantic being Mitford sound. The general altitude of the high plateau is from 4,000 to 5,000 feet, while several peaks rise to 7,000 and 9,000 feet. The excursion steamer sails from one fiord to another in the night time, and the following day is spent in explorations of the interior valley. The soundings of the mouths of the fiords indicate depths of forty fathoms and less; but farther in they exceed 100 fathoms. On the opposite side of the ridge the corresponding fiords may be recognized in lake Te Anan, Manapouri, Wakatipu, Wanaka and Hawea, all of which are true glacial lakes formed by the damming of the fiord by terminal moraines. There may have been here a different change of level, because the present outlet of the lakes are much higher than the inlets to the sounds.

Plate xxiv represents the present locations of the active glaciers; the areas occupied by the ice at the time of maximum glaciation; the positions of the fiords and glacial lakes, and several glacier fans or river deposits, perhaps partly marine. The map is defective in that I have been unable to present all the glaciers and the extreme limits of the fans and plains. There must be a multitude of glaciers northeasterly from the region of Mt. Cook, or the southern alps, and possibly a few in the snow fields bordering the sounds.


1
Mt. Cook
Rakaia River
Waitaki River
Mackenzie Plain
Clutha River
Mataura River
Oreti River
Waiau River
Milford Sound
Lake Wakatipu
Lake te Anau
L. Manapouri
● Living Glaciers
Ancient Glaciated areas
Glacial Fans, River-Deposits
42
43
44
45
46
168
169
170
171
172

The most southern important fiord valley is that of the Waian river with lakes Manipouri and Te Anan, supplemented at its northern end by the Clinton valley; a hundred and twelve miles long, with four prominent tributaries upon the west side. Waian river discharges from lake Manipouri fifty miles from the sea, with the altitude of 591 feet. Te Anan is only four miles distant from Manipouri, with the altitude of 694 feet. Its bottom is 600 feet below the level of the sea. The Clinton valley is a gorge after the manner of the Yosemite, about half a mile wide, twelve miles long, and with precipitous sides from 4,000 to 5,000 feet high—the distant peaks rising to 7,000—and the saddle at the hight of land leading to Milford sound is 3,400 above the sea. Several glaciers discharge into the Clinton valley. Just beyond are the famous Sutherland falls, consisting of three leaps, the upper 815, the middle 751, and the lower one 338, giving a total of 1,904 feet, all visible from one point of view.

Wakatipu lake represents the next fiord valley on the south-eastern side of the highlands. Its former outlet seems to have started at Kingston, and connection made with Mataura river, coursing about one hundred miles to the sea. The moraine at Kingston is easily made out. At several localities along the Mataura river ancient extensive flood plains with clear cut terraces are in evidence. The lake is fifty miles long and usually two miles wide, in a fiord valley. The surface of the water is 1969 feet above the sea, and from a few soundings, the bottom is proved to lie lower than the present sea level. Embossed ledges may be seen at several places, but they are somewhat obscure, largely because of the supposed great lapse of time since they were covered by the glacier. Mountains like the Remarkables border both sides of the lake, rising more than 6,000 feet above it, and it is easy to see the upper limits of the glaciated rocks, reaching up their flanks more than 2,000 feet. The surface of the mountain shows the differences between the glaciated and unglaciated sections just as in the Swiss alps, only they are less clear cut. At Queenstown, about midway of the lake, the present outlet through the Kawaran river starts out and reaches the Clinton in the distance of twenty-seven miles. There are five terraces at the outlet (Frankton) and at Queenstown, each about 150 feet high, and at the mouth of

the Shotoon river below Frankton the delta is about 400 feet high. The Shotoon and Arrow rivers have been famous for the large amount of placer gold contained in these drifted sands. Near the north end of Wakatipu, there are other clear cut terraces at least a hundred feet high upon the Buckley Burn, three upon the south and five upon the north side. At other localities along the lake the levels of the terraces are frequently higher where the tributary streams discharge than upon either side. Plate xxvi is a view looking northerly up the valley of Dart river, away from Wakatipu. The light colored flat consists of sands and gravels constituting the existing flood plain, perhaps not over two feet higher than the lake, and derived from the glaciers of Mt. Earnslaw, 9,165 feet, and the Snowball glaciers, covering the divide between the Dart river and the northerly flowing streams beyond. The flood plain is two miles wide and is full of inosculating streams. The snowfields on the right in the figure are those of Mt. Earnslaw; those on the left in the distance cover Cosmos peak; the snowball glaciers are not visible. In some of the high mountains bordering lake Wakatipu are caves containing numerous bones of the extinct Dinornis. The Clutha river combines the drainage of lake Wakatipu with that from Wanaka and Hawea, two large lakes still further to the northeast and fed by glaciers. Its course is winding, and the valleys narrow reaching the sea near longitude 170°. At Balclutha, near its mouth, are enormous accumulations of loess.

THE SOUTHERN ALPS.

The fiord section is followed by the southern alps, where are the greatest elevations and the most extensive glaciers existing upon the island. The government has had surveys made of the region, and the higher peaks have been climbed by amateurs from Great Britain. It is the policy of the government to encourage tourist travel to this and other interesting regions, and they build the roads, erect the hotels and places of refuge at the public expense. In the Alps the principal hotel is known as "The Hermitage," convenient to the ends of the Horkon, Mueller and Tasman glaciers. Plate xxv is a copy of the principal features of a map of the southern alps after Fitzgerald, who utilized the work of the government surveyors,

MAP OF THE SOUTHERN ALPS OF NEW ZEALAND. [AFTER FITZGERALD.]

... VALLEY. FROM PARADISE FLAT. HEAD OF LAKE WAKATIPU.

adding his own observations. The area is about thirty miles by eighteen, and the glaciers are situated upon both sides of the main divide. The books of Fitzgerald, Harper, Mannering and Green contain the records of explorations and ascents as thrilling and daring as any in alpine annals. Mt. Cook, the highest of the peaks, was first practicallv ascended by Rev. W. S. Green, in 1882, and later by Zurbriggen the celebrated Swiss guide, in 1895, who had gone to New Zealand in the employ of E. A. Fitzgerald.

The Tasman is the most important of all these glaciers. It is eighteen miles in length, rising between Mts. Elie de Beaumont and Darwin, 10,200 and 9,715 feet high, and receiving as tributaries on the left the Rudolph, Forrest-Ross, Kaufman, Haast, Freshfield, Hochstetter and Ball glaciers; on the right Darwin, Bonney, Beetham, Barkley, Langdale, Walpole, Reag. Dorothy and the Murchison, second only in size to the Tasman. The water from the Mueller and Hooker glaciers joins the drainage from the Tasman below the Hermitage, which gives a more extensive flood plain than that described for the Dart river. The Tasman has the altitude of 6,136 feet two and a half miles below its remotest beginning, falls to 4,178 feet opposite the Hochstetter glacier, where it is entirely covered by moraine material. This debris covers six and one-half miles extent of the lower part of the Tasman, being one and one-fourth miles wide at its lower end and two miles wide at the union with the Murchison. It is less than three-fourths of a mile wide for three miles of its course and broadest high up between Mts. Beaumont and Darwin. The altitude of the surface of the ice at the terminus is 2,490 feet, the wall being 140 feet. The moraine is continuous for eleven miles from the terminus up to the head of the Rudolph glacier. Hochstetter glacier starts in a great oval mass, two by three miles in extent, between Mts. Cook and Haast, making a great plateau on the north, and joined by the two tributaries Linda and Adamson on the south, and the united mass falls over a precipice nearly 2,000 feet high before uniting with the Tasman. The pieces unite by regelation and move four miles down the slope. On the west edge of the Tasman, upon the moraine descending from the Ball glacier, a hut has been erected for the accommodation of travellers, 3,402 feet high, and twelve miles distant

from the Hermitage, 2,506 feet, and it can be reached easily by horses. It is a very convenient starting point for the exploration of the Mt. Cook region. The total area of the Tasman glacier is twice that of the Aletsch glacier in the Swiss alps.

The Murchison rises farther to the northeast than the Tasman, from Mt. Cooper 7,837 and Aylmor 8,819 feet, and curves so as to move southerly at the altitude of 5,791 feet. Mannering joins it at 5,084 feet, followed on the same west side by the Dixon, Wheeler, Baker, Cascade, Onslaw and Barnett, glaciers. The Harper and Aider glaciers are tributary on the east side near the upper limit. The Murchison makes a sweep of 180° before being joined by the Mannering, which has brought some debris to cover its own mass, while the Murchison is free for a mile and a half below the junction. The extreme length of the moraine covering is four miles, and the lines of blocks are distinct as they are upon the Tasman. Each tributary pushes debris upon the main glacier whose angles of direction soon change their course to fit the motion of the larger mass. The extreme length of the Murchison glacier is eleven miles, with the usual width of a mile. Below the terminal cliff vigorous streams of water meander across the valley for five miles till it reaches the Tasman, and then the water is crowded to the east side of the ice. The terminal cliff is eighty feet high or 3,385 A. T. The flood plain below commences at 3,308 and strikes the Tasman at 2,869 feet, a fall of eighty-eight feet per mile

The Mueller glacier reaches nearly to the Hermitage and has piled up a huge moraine 250 feet high behind the hospice. A general view of the lower portion shows morainic bands very similar to those upon Agamir's classic diagram of the Viesch glacier. The Hooker glacier comes down from the west flank of Mt. Cook and exhibits finely the moraines and the ribbon structure of glaciers. It is formed by the union of the tributaries Empress, Noeline and Mona glaciers.

The other glaciers shown upon the map are tributary to the rivers draining the northwest slope of these alps; being at the south, the Twain and Copley, branches of Karangua river; then the Cook, the Balfour and Fox branches of Cook river; the Wakupapa and Waiho rivers. The Douglass glacier is in

two parts; the highest commencing as névé upon the west flank of Mt. Septon, and running parallel with the main glacier for four miles, and supplying it with avalanches along its whole course, nowhere touching the lower body. The precipices over which the ice falls vary in hight from 200 to 1,500 feet, over which avalanches fall from twenty to twenty-five feet every hour. Arrows upon the map indicate the general direction of this movement.

The Fox glacier has been explored considerably because it is the nearest of the west coast glaciers to settlements, and descends the nearest to the sea level (734 feet). Cook river of which the Fox is a tributary, is a "wide unsightly stretch of shingle flats covered with large masses of drift timber, through which the water meanders in numberless channels." At the mouth of the Fox branch these flats are two miles wide. Some of the moraine piles reach the hight of 1,500 feet. The principal tributary of the Fox is the Victoria glacier, whose terminus is over a precipice one thousand feet high. The Fox arises from the western slope of Mts. Haidinger and Tasman, and is ten miles long with a remarkable local névé at its source. The terminal face is 756 feet high, and is covered by debris for fifty chains. It is said that the retreat from melting is apparent in the middle rather than at its end. Measurements in the winter showed a motion in this glacier from twenty-one to thirty-one feet in twenty-eight days. Near the lower end there is a fine hot spring and a boulder thirty feet high and three hundred and fifty in circumference. Tony's rock, lower down, is 156 feet high and has a diameter of 268 feet. In the Copeland valley Fitzgerald measured a boulder 300 by 200 by 100 feet in linear dimensions and "there were others still larger." There is a large tree growing upon the top of one. I have not seen any notice of any larger boulders than these are in any glaciated district, and their immense number interferes seriously with exploration.

Observations upon the rate of motion of several of these glaciers have been made with care. On the Tasman, in the summer, the average daily rate was from ten to eighteen inches; in the Murchison, the average daily rate was from one-half to seven or eight inches; on the Hooker, from 1.1 to 5.4 inches; on the Mueller from 4.1 to 9.6 inches. The Franz Joseph gla-

cier gave numerous examples of daily motion up to 180 inches and several to 207. This glacier reaches a lower limit before disappearance than any other except the Fox.

Mr. Harper has summed up his observations for a series of years upon the recession of the glaciers, "that at present the New Zealand glaciers are not receding to any appreciable extent." The Spencer and Franz Joseph are retreating, the Tasman is advancing rapidly; there is no change in the Fox, Mueller, Hooker and Burton, and in all the chief glaciers there are no marked signs of recent changes. The government surveyors have placed numerous monuments to record future changes.

GLACIAL FANS AND FLOOD PLAINS.

The most important feature in New Zealand glaciation is the great area of the glacial fans and flood plains, and we can witness their formation. The larger streams are not bridged for ordinary highway travel, and fording is oftentimes dangerous. Many persons, including scientific explorers, have lost their lives while attempting the passage of these streams. The stage route to the Hermitage from the end of the railway makes a long detour of a whole day's travel in order to avoid the fording of the Tasman river. This river may illustrate the features of the discharge and flow from the greatest ice mass. The stream at the end of the ice is 2,456 feet A. T. and falls to 1,717 feet at lake Pekaki, about twenty miles. Very strong rapids mark the beginning of the flow and there is little opportunity for vegetation to gain a foothold upon any of the shoals and quicksands. Several terminal and many lateral moraines skirt the banks. Lake Pakaki is twelve miles long and exists because of terminal moraines blocking up the valley, whose concentric arrangement can be easily made out—three miles broad and 250 feet high—just below the outlet a recent cut is very marked, 180 feet high. The upper sixty feet consists of white silt, and the lower part is of ordinary stony till. Ancient glacial lake markins, the highest coinciding with the summit of this cut, were noted in the valley above the outlet. The river flows ninety-eight miles below Pakaki to the sea, an average of seventeen feet to the mile, oftentimes too rapidly for canoe navigation. Two other glacial lakes, Tekapo and Ohan adjoin Pakaki, and their combined outlets constitute the Waita-

ki river. The map, Plate xxvi, will give some idea of the extent of this deposit, as it constitutes the "Mackensie Plains." According to Dr. Haast this area indicated the presence of a trunk glacier thirty miles broad with three outlets besides the one on the Waitaki. Its thickness must have been 5,000 feet and the ice extended to a point twenty-five miles from the sea, giving 112 miles as its length.

Similar statements may be made about the former extent of glaciers upon seven large rivers in the province of Canterbury, between latitudes 45′ and 43′. At the lower ends of the glaciers the fans commenced, whose general extent is indicated upon Plate xxiv. Because the region is the most thickly populated the Canterbury plains have been carefully explored, and by measurements made it is certain that there is a gradual rise from the ocean inland up the Waimakariri, Selwyn and Rakaia rivers in deposits of gravel, sand and silt, of material derived from the upper reaches of the streams scores of miles away. The plains are the "deposits of huge rivers issuing from the frontal ends of gigantic glaciers. According to Dr. Haast the Selwyn river flowed at the junction of the fan of the Waimakariri and that of the combined Rangitata, Ashburton and Rakaia rivers further southwest. The Banks peninsula was an island of igneous rock and has caused the junction of the fans with the marine wash of the fluviatile detritus, leaving still a considerable space unfilled, called lake Ellsmere. The glacial origin of the shingle can be well appreciated as the glacialist looks from his train crossing the rivers named above.

CONCLUSIONS.

Some general conclusions may be given without further detail:

1. The New Zealand glaciers are all of the Alpine type—they don't pass the larger watersheds—and they are simply extensions of the present ice system. There are no true erratics, *i. e.* blocks which have been transported from one drainage system to another. Hence there was no continental ice sheet. Usually the glacier did not reach the seashore, and thus far no Arctic marine shells have been discovered in the sands.

2. The glaciers of the Southern alps are larger and finer than their congeners in the Swiss alps. Hence there is a

larger virgin area open for Alpine tourists. Many of these peaks and ice plains await the tread of explorers. Mt. Septon is the Matterhorn of the Southern alps, rising from the valley to fully as great a hight as does its prototpye from the village of Zermatt and at a steeper angle. At the Hermitage there is a constant series of avalanches, startling one by their deafening roar, and being plainly visible.

3. There are peculiarities in the various phenomena. Lateral and terminal moraines constitute the bulk of the deposits, containing very few scratched stones. There is no ground-moraine, or boulder clay containing glaciated pebbles. Silts are not uncommon. Eskers and drumlins have not been observed. Loess is recognized at several localities, always of aqueous origin. Embossed rocks and smoothed surfaces are less conspicuous than in New England, and it is claimed that their obscurity is due to their great age. Glacial striæ are scarce and none are found upon the tops of ridges. The scarcity may be due in part to the absence of protecting till.

4. To an American the glacial fans are the most conspicuous and characteristic features of the New Zealand ice work. All the rivers proceeding from the existing glaciers are very turbid, and of large volume in the summer season. In this respect they strongly contrast with the streams coming from highlands without ice, which shrink to small dimensions or dry up. The first may be styled *snow rivers,* and the second *rain rivers.*

5. The opinion prevails at the antipodes that the greatest extension of the glaciers occurred in the Pliocene period. Capt. F. W. Hutton in a table of the sedimentary formations in New Zealand, assigns the older glacial deposits to the older Pliocene* at the base of the Wanganui system, whch is the equivalent of the Pliocene. He concludes that the "former great extension of our glaciers was caused by greater elevation of the land during the interval between Paseora [Miocene] and the marine beds of the Wanganui system."*

Sir James Hector, director of the Geological Survey, says that the Pliocene was characterized by the "greatest activity of the volcanic forces"; and in the south island "the great area of land above the shore line intensified the erosive action of

*Quar. Jour. Geol. Soc., vol xli, pp. 194-211.

the glaciers radiating from the mountain centers, and gave rise to enormous deposits of gravel, such as compose the greater part of the Canterbury plains" etc.* Dr. Haast refers the glacial deposits to both the upper Pliocene and Pleistocene.† A very natural conclusion may be that the glacial age in New Zealand, representing that of the antipodes generally, preceded the same period in the northern hemisphere. This will help us in formulating glacial theories, since both polar regions were glaciated alternately.

6. The large cursorial birds, or the *Moas,* of which eighteen species have been described, seem to have flourished in the ice age and the early Pleistocene. From a study of the distribution of the genera and species it is concluded "that the two islands of New Zealand were separated from each other after the development of most of the genera, but before the development of the known species, except of course Anomalornis antiquus of the Miocene, and that they have not since been united." The older deposits are in the gravels and caves, the latter in turbaries. For convenience I add a list of the species, after Captain Hutton. A. oweni, Haast; Dinornis giganteus, Owen; Megalapteryx tenuipes, Lyd.; Cela carta, Owen; D. ingens, Owen; Anomalornis gracilis, Owen; Euryapterx exilis, Hutton; D. struthioides, Owen in part; A. didiformis, Owen; Pachyornis, rothschildi, Lyd.; P. pygmaeus, Owen; Dinornis dromæoides, Owen; Palapteryx geranoides, Owen.

From Trans. New Zealand Institute, 1896. Nearly all these species are reproduced in the Canterbury Museum at Christ Church. This collection has been built up chiefly by means of exchanges of the Dinornis bones with other objects, with European and American institutes. Dr. Julius Haast founded the museum and Capt. F. W. Hutton is its present director.

*Catalogue of geological exhibits at the Indian and Colonial Exhibition, London, 1886.

†Geology of Canterbury and Westland, p. 251. 1879.

REEF STRUCTURES IN CLINTON AND NIAGARA STRATA OF WESTERN NEW YORK

By CLIFTON J. SARLE, Rochester, N. Y.

PLATES XXVII-XXXI.

At no other point in the United States, excepting possibly Niagara, the type locality, is there so fine an opportunity to study the Niagara series, as in the lower gorge of the Genesee, at Rochester, N. Y.; and the display of Clinton strata is unequaled.

A phenomenon which early drew the writer's attention in the study of this exposure, is the occurrence in the Clinton upper limestone of certain irregularly bedded masses which, owing to differential weathering, project beyond the general ledge face, being apparently parts of irregular lenses.

In the various exposures of this horizon, for about a mile along the Genesee, upwards of forty examples have been observed, this number being increased by others found in sewer tunnelings in the northern quarter of the city. The "west side" sewer, made in the winter of 1895-6, afforded seventeen masses in a distance of seven or eight hundred feet. The workmen engaged in this excavation called them boulders because of their shape and superior hardness. The latter character probably accounts for their prominence on weathering surfaces.

Outside of Rochester I have found them along the Clinton outcrop as far as Niagara river on the west and Marble (Second) creek, Wayne county, on the east, a distance of about one hundred and twenty miles. Over one hundred examples have been more or less carefully studied by the author. They are absent from extended areas or may occur isolated, or in groups, or so near together as to more or less completely coalesce. At Niagara gorge and under Lewiston heights, eleven examples have been observed, but between this locality and Lockport an outcrop twenty miles in length has afforded but four. At Gasport in the bed of the creek nearly a score are seen. In Monroe county, nearly every outcrop affords one or more, often twinning, and at Marble creek they form an irregular continuous stratum, extending for several rods along the bed of the stream, though absent from Salmon creek three

FIG. 1. Mass formed of two unequal growths of Fistulipora extending through the upper six feet of Clinton upper limestone into the base of the Rochester shale. Dimensions 32 x 11 feet.

FIG. 2. Remnant of eroded mass, showing shale encroachment, pocketings, etc. Spaces between limestone layers formed by removal of shale. A—10 inch stratum, flexed in conformation to removed part of the mass; B—thickened stratum at side of Fistuliporid head; C—oldest remaining portion of the mass; D—Rochester shale. Breadth 18 feet.

FIG. 3. An oblique growth which probably started in the depression at B. The line of growth, C, is made of imbricating dome-shaped shells of Fistulipora. The oblique axis is fully 12 *feet long*. A—Rochester shale. B—portion chiefly Trilobites and Cephalopoda.

REEFS IN THE GENESEE RAVINE AT ROCHESTER.
Above the R. W. & O. R. R. bridge.

miles to the westward. The Clinton masses are limited to the upper half of the Clinton upper limestone or projecting into the Niagara shale above, but occur at varying horizons within this limit; neighboring masses usually start at about the same base level and by far the greater number but a little above the mid-plane of the limestone stratum.

In general these accumulations may be roughly compared to greatly thickened lenses. [Pl. xxx, Fig. 7.]* However, they may be elongated or oblique to the vertical axis. [Pl. xxvii, Fig 3.] In size they vary considerably. The extremes observed range from one to fifteen feet in thickness, and in breadth from two to fifty feet, though they may, as cited at Marble creek, form an irregular, continuous stratum.

The strata above and below the lenses are often so strongly bent in conformity to these less-yielding masses as to produce an arching or doming of the overlying Rochester shale and a sagging or basin-like depression which extends into the Clinton upper shale beneath. This deformation, taken with the rough and irregular structure, gives them the semblance of inclusions. More careful inspection, however, shows the limestone strata on either side continue as a rule into the mass [Pl. xxvii, Fig. 1], where they may double in thickness and the bedding becomes lost in the obscure structure. Shale partings thin out as they reach the lens or encroach but a little distance upon it, [Pl. xxvii, Fig 1.] with only rare exception appearing to extend through, dividing the mass into upper and lower portions. Beds running into the upper portion are traced with upper flexure, those into the lower portion with a downward.

From these facts it would appear that the lenses were produced by local thickening of the successive limestone layers in the process of their deposition. Hence it is to be inferred that their construction was not rapid, but in some instances continued through the time when the latter half of the limestone was accumulating, and possibly during the beginning of the Rochester shale.

At Rochester this horizon, being a plane of subterranean drainage, has suffered considerable mineralization and dissolution. This is shown by numerous small cavities spanned by

* The photographs reproduced as plates 27-30 were taken by Mr. George W. Kellogg, of Rochester, several of them under difficulties. The writer is greatly indebted to Mr. Kellogg's photographic skill and intelligent interest.

needles of celestite, and the abundance of small spherules of marcasite. In the lenses themselves cavities filled with gypsum in four or five pound masses are common. At Niagara several of these cores have been found weighing from ten to fifteen pounds. [Pl. xxix, Fig. 6.]

The rock is apparently a structureless, exceedingly compact, dolomitic limestone, breaking with an imperfect conchoidal fracture. In color grayish blue, it weathers, like the including beds, to a light brown or yellowish hue.

Only by weathering is the true character of these masses clearly brought out, and a satisfactory explanation of their origin made possible. Then they prove to be mainly composed of a remarkable development of fistuliporid and other bryozoan forms, and to contain unusual accumulations of cephalopods, trilobites and brachiopods. Many of the species are rare or unknown in the surrounding limestone.

The lenses of Rochester alone have yielded, exclusive of the Bryozoa, which will probably add very materially to the number, sixty-eight genera, ninety-nine species and two varieties, disposed as follows:

Class.	Genera.	Species.	Variety.
Sponges	2	2	—
Corals	3	5	—
Crinoids	4	4	—
Cystids	1	1	—
Tubicolous Annelids	2	2	—
Brachiopods	29	35	—
Pelecypoda	5	9	—
Gasteropods	5	7	—
Cephalopods	3	8	—
Ostracoda	1	1	—
Trilobites	9	10	2
Total	68	99	2

PREVIOUS OBSERVATIONS.

This phenomenon was observed by Dr. Eugene N. S. Ringueberg* in Clinton and Niagara strata in the vicinity of Lockport and Gasport. He found them in restricted areas and of extremely variable thickness, appearing to be limited to the capping plane of the Clinton upper limestone. In view of the irregular and undulating appearance of the upper surface and

*"The Evolution of Forms from the Clinton to the Niagara Group." Am. Nat., September, 1882, p. [illegible]

the position of many of the fossils, he considered these bodies accumulations of organisms swept together by eddies and currents charged with the fine sedimentary matter in which we now find them. Dr. Ringueberg listed forty-eight species.

Prof. J. M. Clark under the announcement "Faunal Colonies in the Clinton beds,"* mentions the occurrence of these bodies in western New York through Orleans and Niagara counties. He describes them as lenticular masses of limestone ten to thirty feet in diameter and entirely disconnected, those in one plane lying imbedded in the midst of the Clinton limestone, though of wholly different texture and composition therefrom; in another, lying in the shale above the limestone and displacing or being surrounded by the lower shaly beds of the Niagara group (Rochester shales).

Amadeus W. Grabau, in his "Paleontology and Geology of Niagara Falls and Vicinity,"† under the heading "Limestone Lenses of the Clinton" says: "At intervals in the upper Clinton limestone may be seen large lenticular masses of compact, hard, apparently structureless limestone, often concretionary and not infrequently showing numerous smooth and striated surfaces of the type known as 'slickensides' and which are indicative of shearing movements."

He mentions the lenses in the Rome, Watertown and Ogdensburg railway cut under Lewiston heights, as entirely imbedded in the limestone from which they are differentiated by their structureless character. He also notes the mass seen in the New York Central railway cut on the side of the gorge near the third watchman's hut (see Fig. 6.) as lying between the upper limestone and the overlying shale, partially imbedded in both. He finds those under Lewiston hights rich in orthoceratites and shields of trilobites; and those of the gorge yielding chiefly brachiopods. From these lenses he lists twenty-eight species. Dr. Grabau observes that the origin of these lenses is still obscure.

THEORIES OF ORIGIN OF THE LENSES.

By Mechanical Agency: The presence of currents which would enmass such quantities of organic material in comparatively small spaces should have left other conspicuous struct-

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***Report of the State Paleontologist* for 1899 (pub. 1900).
†*Bulletin, N. Y. State Museum*, No. 45, vol. ix, April, 1901, pp. 99-102.

ural features, those observed being wholly disproportionate to the magnitude of the result.

The appearance of barren shale partings, going east from Niagara county, is evidence that the limestone making phase, dominant during the formation of these lenses, was interrupted by the incursion, from time to time, of mud-bearing currents from the shores of the eastern interior sea which lay to the north and east. Disarticulated brachiopods and dismembered, partially triturated, crinoidal remains, of which the including layers are composed, and occasional overturned Favosites found upon some of the surrounding limestone surfaces are regarded as other indications of currents. But the uniform thickness throughout different parts of the layers and their persistency, indicate that these currents were weak. Further, the remains of Bryozoa and other organic matter comprising these masses, often bulky of form, if enmassed by the impelling force of moving water would require strong currents or even wave action. But the absence of water-worn and broken shells within these masses, and of cross bedding and current channelings in the surrounding limestone is significant. This is strikingly illustrated by the beehive-shaped mass at Niagara gorge above the whirlpool. [Pl. xxvii, Figs. 5 and 6.] This heap of organic remains rises steep-sided eight or nine feet above the surrounding limestone surface, and nowhere either in or about the mass are the above conditions indicated.

The fine preservation of much of the organic material seems to point to its comparatively undisturbed condition after death; and the great number of rare forms, some not found outside of these masses, can hardly be credited to the sorting or selective power of currents or eddies.

There appears no reason to doubt that these masses were to some extent influenced by currents, but that any of them owe their origin wholly to this agent is improbable. The gentle movements of the water are regarded as only a modifying influence to some more important agent.

By Organic Growth: The explanation of origin is found in the bryozoan matter. The axes in all cases are large masses of fistuliporids. These organisms are always in position of growth, and practically do not occur outside of the lenses. That their position is normal is determined by examining their

surfaces, and it is further proved by the great size of the concentric masses found in these lenses. This life once established, the growth keeping pace with or in advance of the slowly accumulating marl sediment, would through a long period of time produce essentially this phenomenon. That no other element is necessary is proved by masses bearing scarcely a trace of any other organism.

Great detached cores of this material often suggest, from their formal resemblance, great heaps of poorly mixed dough. Some growths with a fine sedimentary coating filling the pores, have the appearance of concretions, an impression which is hightened by the structureless character, usually revealed upon fracture. Concretions appear, however, to be entirely lacking in these lenses.

The indications are that these masses were not formed by the growth of any one colony but that the surfaces were constantly receiving accessions of new colonies springing up and spreading over the old detritus-laden surfaces, some of these frequently attaining considerable size. It appears from macroscopic examination of these surfaces, that two or three species of *Fistulipora* are represented, though but one is important as builder of these masses. The framework and bulk of all these lenses is seen to be bryozoan.

The irregularities of structure and outline observable in those masses is mainly the result of the influence of mechanical forces upon the bryozoan growth. Most important of these influences was the silt deposited during the muddy-water phases, indicated by the shale partings in the eastern portion of this area. The prominence of some of these masses undoubtedly enabled the currents to keep them partially free from silt, probably facilitated in no small degree by the life functions and activities of these living surfaces. Thus where the life was vigorous and considerably in advance of the floor deposit the sedimentation is seen to have had little effect. This is shown where shale layers perhaps three or four inches in thickness encroach but a little way or end abruptly at the side of a fistuliporid growth. [See left side of Fig. 1, Pl. xxvii.] Any loss of territory in this case appears usually to have been quickly made good by the more vigorous growth set up with the returning clear water conditions. Where the growth was

weak and but little above the level of sedimentation, the silts are seen to have encroached from all sides and to have filled the depressions in the irregular surface [Pl. xxvii, Fig. 2], some times nearly or quite covering the mass. Usually these encroachments are one-sided, depending upon the configuration of the mass and possibly upon the direction from which the currents came. In such cases the surviving life, starting up afresh, is seen to have formed a new growth often quite distinctly defined and resting well over upon one flank of the parent mass. In many cases this was repeated several times, though not always so conspicuosly, the surviving life each time lying in a little different quarter. The limestone layers extending in upon these thin shale partings to the new life centers, are often flexed and thinned before being augmented by the local growth. [Pl. xxvii, Fig. 2.] Silt patches usually produce an imperfect layering within the lenses and sometimes recurring several times in the same vertical line, produce a bedding corresponding roughly with the planes of sedimentation without. Figure 1, plate xxvii, is of a mass which appears to be made up of two nearly independent growths of fistuliporids, with slightly diverging axes. The imperfect layering in the space between the two halves, was maintained by silt pocketing.

In some instances life may have been completely smothered out and the elevation remaining became later the site for new fistuliporid colonies. This is difficult to determine, owing to some part of the mass always being broken away or remaining imbedded. Of two neighboring masses, on the Genesee, the growth of one is seen to have stopped at a certain silt plane, while the other is divided by it into distinct upper and lower portions. It is the impression however that there must have been some life connection between the two growths.

Another mass at the same locality had somewhat the shape of an hour-glass. The narrow neck of lens rock which connected these two parts or lenses, probably represented the thread of life surviving the silt girdling. This life at last regaining vigor and extent was finally smothered out by another and heavier blanket of fine mud, indicated by the shale which covers its summit.

The presence of silt, where not sufficient to smother the growing surface, seems in some cases to have caused the bryozoan growth to enroll and knot in an unusual degree.

The growth of new colonies upon these surfaces, the silt encroachments and consequent shiftings of growth and concurrent irregular bedding, all combined to produce some very complex structures. But the life of these masses passing roughly through a maximum to a decline, the resulting form is nevertheless always sub-lenticular.

Currents evidently played an important part in the disposal of the lighter material growing upon and about these sites. This is proved by the contents of the rim-like thickenings sometimes observed, where a limestone tier abuts a fistuliporid growth, which was in advance of the plane of sedimentation. The thickening (A) on the left side of the well-defined fistuliporid head [Pl. xxvii, Fig. 2.] is made up of fragments of delicate funnel-form and dendritic bryozoans, disarticulated brachiopods and crinoidal fragments. The bryozoan material growing less and finer a few feet out from the mass, and its abundance upon these sites, indicate its source. The crinoidal rubble being more abundant farther out upon the slope, suggests that this material was drifted from outside. Crinoids evidently grew very abundantly over the level floor, their remains contributing more than anything else to the formation of the including strata. A remarkable thickening, made up mainly of crinoidal fragments, is seen on the eastern side of a mass east of the station at Lewiston hights. Currents approaching or leaving these masses appear in either case to have added to these marginal deposits. Some of the rock formed from the light, portable material collected in this way suggests Coquina limestone after the fine filling is weathered out.

An interesting problem is presented by two masses on the Genesee which stand so near together that their inner margins are scarcely five feet apart. One, six feet in diameter, is composed almost wholly of fistuliporid material with scarcely a trace of crinoids; the other, twenty-five feet in diameter, and starting at the same level, is made up in the peripheral portion almost exclusively of crinoidal debris. This suggests that the latter had a fringing colony of crinoids.

Where sedimentation was nearly apace with the bryozoan growth, the fistulipora, by repeated extensions over the fragmental matter collecting upon its margins, often formed an interweaving so complete that the passage from the mechanical deposits to those of life-growth is difficult to determine.

In the masses where the lighter material was particularly abundant, a slight shifting has resulted in an imperfect layering, and sometimes encumbering the surface which must have interfered nearly as seriously with the fistuliporid growth as did the silt.

From the small size of these masses and the manner in which the lighter material is disposed about them it is seen that they could not have been an important source for the supplies of organic matter which compose the including limestone strata.

Though many forms of life appear to be especially associated with the peculiar conditions found upon these sites, yet many others found here are cosmopolitans. The level floors were evidently richly covered with life, though not comparing with the luxuriance of these tumuli and their immediate neighborhood. Some forms seem to have preferred the level stretches just as others preferred the fistuliporid sites. It is probable however that with favorable conditions for preservation the level floor would be found to include them all; as primarily it must have been the source. More extensive collections will do much to clear this point. When we compare the contents of different layers of a stratum which vary considerably among themselves in their assemblage of forms with the contents of the lens-rock proper we find that the principal form or forms of a given layer are oftentimes not shared by the lenses at or above that particular level. For example in Rochester a ten-inch layer, the thickest in the upper six feet of this limestone, abounds in *Whitfieldella nuciformis*. This layer abuts, and in many cases fuses with, lenses, yet rarely is this brachiopod found in them.

Weathering brings out the organic features though slowly and superficially. A lens partially blasted away in 1885, in the extension of a sewer down to the water level of the Genesee, has weathered so far as to show how completely the mass is made up of Fistulipora, but under a blow of the hammer, the

rock splinters reveal a structureless bluish gray surface, with no trace of organic contents.

The lenses at Niagara and vicinity generally exhibit a more uniform aspect than those in the eastern portion of the area, due to the smaller percentages of silts, the upper ten feet at that locality forming a solid bench. [Pl. xxviii, Fig. 4.]

Owing to the well defined bedding planes in the limestone at Rochester, [Pl. xxvii, Figs. 1 and 2.] these features may all be studied there to particular advantage, affording an unequaled opportunity for comparisons. It is possible to trace any of the shale partings from one neighboring mass to another, thus enabling one to see its relation to several of these growths, or to examine several limestone floors in their vicinity in the same way...

While these masses were similarly affected by general conditions yet in each we find many features that are specific; showing that each lens had a history differing from that of every other.

ASSOCIATED LIFE.

Attached Forms:—The associated life usually found upon these fistuliporid masses shows them to have been mainly centers for other attached forms. This is probably due to the fact that the free larva of the smaller and more delicate bryozoans, and of brachiopods in particular, required some firm base for attachment. Freely distributed in the sea, they settled everywhere, but lived in greater numbers upon these hard surfaces, there finding this prime essential to their existence. One of the best examples of this is found in Niagara gorge on the New York Central and Lewiston railroad, at the third watchman's hut. [Pl. xxix, Fig. 6.]. This mass is thirty feet long and ten feet high. Brachiopods probably make as high as thirty per cent. of the contents. In some parts their shells are so abundant as apparently to have nearly smothered out the bryozoan nucleus. In the mass proper the brachiopods are entire and appear to have been largely covered by the bryozoan growth, thus preserving the valves intact. Some of these are evidently in position of growth.

Other Forms:—Thus inhabited these sites attracted other forms which in turn drew others, until they became rich feed-

ing grounds, teeming with life. The favorable conditions are shown by the large size of the trilobites, *Calymene* and *Ceraurus*. The head shields of the latter often indicate individuals five or six inches long. In these facts we find an explanation for the occurrence in these lenticular thickenings of communities of brachiopods, for the aggregates of cephalopod shells, for the great numbers of trilobite moultings, and for the abundance of many otherwise rare forms.

The manner of occurrence of the trilobites is striking. Their exuviæ are commonly found in groups or pockets, sometimes of one species, but more often of two or three. They may appear to be entirely absent from some masses, or to occur in two or three parts, or at distinct levels in the same mass. The head and tail shields of *Illaenus* are almost invariably inverted and generally packed together, one inside the other, like broken egg-shells. These cachements may represent the action of light currents in shifting the tests into depressions in the irregular surface. But the position of some of these moultings suggests that they were left in crannies and silt-lined depressions which were inhabited by trilobites, attracted to these growths by the food supply. Outside of the lenses trilobites are rare.

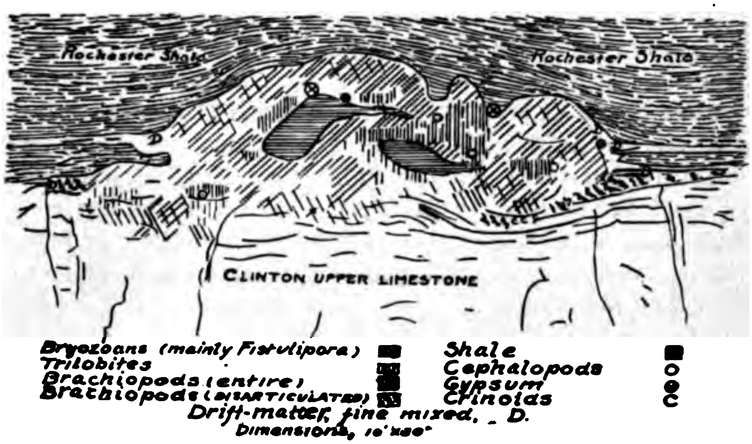
Cephalopods are not unusual in the surrounding limestone but in the lenses they occur grouped like the trilobites. They are commonest in those masses in which the trilobites are found, and the two forms are frequently commingled. All forms, especially brachiopods, lived in communities upon these sites; *Whitfieldella nitida* often occurring by the hundreds.

It thus appears that the comparative richness of these sites is due (1) to the conditions attractive to all forms of life, growing out of the advantages the areas afforded to attached forms; (2) to the anchorage and shelter furnished after death by the bryozoan framework; (3) to the groupings of certain, sometimes conspicuous forms, an outcome of their colonial habits; and (4) to the partial exclusion of silt, the fine material found in these sites being partially formed by decay and gentle trituration of delicate organisms.

This wealth of material and its fine preservation is valuable to the collector, for in these lenses, where well weathered, more material illustrative of the fauna of this clear limestone-forming sea may be found in a much shorter time, than can be obtained in the including beds.

LENSES SURVIVING IN THE ROCHESTER SHALE.

All the lenses observed, with possibly four or five exceptions, terminated with the limestone of which basally they are always a part. One exception is the mass at the third watchman's hut. [Pl. xxix, Fig. 6.]. This starts with a thickening of perhaps the upper two feet of the limestone, of which the capping ten or twelve inches is of darker color and made up of a mass of drifted brachiopod shells and other remains of Niagara type. This stratum is slightly thickened on the right side of the lens and thins out beneath its edge, while on the left side it fuses into the lens. A limestone parting three or four inches thick in the Rochester shale above and midway on its sides, also fuses into this mass. This lens carries several inclusions of shale, apparently of the same character as that abutting its sides and arching over its dome-shaped top. These may have started as surface pockets like those in the top of the same mass [See accompanying sketch], which might



very naturally have become enclosed in the same way had the growth continued longer. These facts point to the growth of the mass contemporaneously with the deposition of the surrounding Rochester shale.

This mass was one surviving the limestone period. The species of brachiopods and bryozoans found are mainly forms known to have lived on into the shale period. This limestone dome projecting through the silt flow, probably con-

tinued for some time to be the center for attached forms. Brachiopods are remarkably abundant in the basal portion and comparatively rare in the upper. This mass also contains several trilobite pockets. The accompanying sketch shows roughly the arrangement of the various elements as displayed in the present section of the mass. From the configuration of the beds beneath on the right side and their slope, it is evident that the portion of the mass broken away extended considerably lower on that side. The extinction of the life of the mass probably occurred about the time the silts reached the level on its sides, indicated by their extension over its top.

The other cases of growth upward into the shale are along Genesee. The upper two or three feet of these masses are made up mainly of an irregular, dome-like, fistulioporid growth, discolored with sedimentary matter, of the same appearance as that of the enclosing base of the Rochester shale. Their life was short after the introduction of the shale sediments.

The conditions for the continued growth of these masses in the shallowing turbid waters of the sea at the opening of the Niagara epoch seem to have been adverse, though more favorable in the western portion of the area. The most injurious was the rapid accumulation of calcareous mud which undoubtedly interfered seriously with the continued local growth of the bryozoan life. This effect is shown in the study of these masses in the limestone where the incursions of mud-bearing currents reduced the growing surfaces which again extended on the return of clear water conditions. The same fistuliporas in the shale never attained a growth exceeding a few inches radius.

COMPARISON WITH EXISTING PHENOMENA.

The fragmental character of the material forming the Clinton upper limestone at the level of these masses, makes it probable that these layers were deposited at a depth slightly within wave-base. The depth can hardly be estimated from assuming a similarity of conditions in any existing sea or bay, for the data available on this subject are found to be discordant. It was probably considerably within the one hundred foot line, a depth consonant with the more vigorous marine growths of to-day.

Thus these colonies of *Fistulipora* with the associated life drawn about them by the very favorable conditions affording attachment, food and shelter, are seen to have formed low, irregular, dome-shaped prominences, upon the broad, level, floor of a shallow sea. They are not known to have ever reached an elevation exceeding ten feet, the approximate hight of the largest yet known. A mass about one-fourth of a mile above that at the third watchman's hut, was estimated to be fifteen by fifty feet.

Their distribution we have seen was irregular, sometimes isolated, oftener in groups covering considerable areas, or, as in one known instance, coalescing to form an extended layer.

In this ancient coral-maker* (for professor Agassiz considers the bryozoan animal such) and the rich concourse of associates indicated, we find life conditions according so well with those observable in the modern reef or coral-field, as described by Darwin, Dana, Agassiz and Kent, that no hesitation is felt in pronouncing these to be ancient coral reefs. While having many of the features common to such structures in general, these little reefs present a more striking analogy to a peculiar kind described as follows by professor Charles F. Hartt:† "So far I have only spoken of fringing reefs, but there are other coral structure of greater interest in these waters. Corals grow over the bottom in small patches in the open sea, and, without spreading much, often rise to the hight of forty to fifty feet or more, like towers, and sometimes attain the level of low water, forming what are called on the Brazilian coast 'chapeiroes', (signifying big hats). At the top these are usually very irregular, and sometimes spread like mushrooms, or, as the fishermen say, like umbrellas. Some of these chapeiroes are only a few feet in diameter. A few miles to the eastward of the Abrolhos is an area, with a length of nine to ten and in some places a breadth of four miles, over which these structures grow very abundantly, forming the well-known Parcel dos Abrolhos, on which so many vessels have been wrecked." Professor Hartt in describing a visit to the northwestern part of this reef, mentions, among other facts: "The chapeiroes, as a general thing, are rarely ever laid bare by the tide." "They are here, as else-

*There is much difference of opinion regarding the position of these fistulip- [illegible] inclined to consider them corals.

† [illegible] 1870. pp. 199-200; also p. 191.

where, of all hights and dimensions." * * * "They do not coalesce here as elsewhere, to form large reefs as they do to the west of the islands."

Professor James D. Dana says of their structure: "The rock of these submerged coral-heads is but a loose aggregation of coral in the position of growth, except possibly, in their lower portion, where the open spaces may be filled with sand and fragments cemented together."

SIMILAR OCCURRENCES IN OTHER GEOLOGIC HORIZONS.

Lockport (Niagara) Limestone:—At Niagara gorge, about one-half mile above (south of) the suspension bridge and one hundred yards north of where the Gorge railway reaches the open face of the ledge beside the track, and at a level twenty or twenty-five feet above the base of the Lockport limestone, is a reef [Pl. xxx, Fig. 8] one hundred ten feet in length and exposed to the hight of twelve feet. It lies in a thin-layered stratum of limestone separating two massive benches. The irregular structure of the reef is in contrast to the thin-layered limestone, while the upper massive bench is arched over it. The reef rock is a compact bluish dolomite, weathering to a yellowish hue. Bryozoans are abundant, often in masses of considerable size; but owing to the comparatively recent date of the railway cutting weathering has done little to bring out other organic contents. It is probable that this mass originated in the same manner as those of the Clinton upper limestone. Other reef masses are conspicuous at this level along the gorge. One seen just north of the eastern end of the cantilever bridge is two or three hundred feet long.

Seventeen miles eastward along the Niagara escarpment and three miles west of Lockport, in a road-cutting, three well weathered masses are exposed at the same level. [Pl. xxxi, Fig. 9]. The first thing that arrests the eye is the loose structure of these masses, strongly contrasted with the firm beds of inclusion. This, coupled with the remarkable assemblage of Niagara forms of bryozoans, corals, crinoids, brachiopods and other types, in a better state of preservation than the organic materials comprising the limestone of enclosure, favors the conclusion stated, that here we have another example of reefs.

*Coral and Coral islands, 1872, p. 142.

Dr. Ringueberg recently directed the writer's attention to a field in the western outskirts of Lockport in which a dozen or more small patches of rock project through the soil, in low, dome-like prominences [Pl. xxxi, Fig. 10]; and expressed the opinion that they are of the same nature as the masses of the Clinton. A visit to the locality corroborated this opinion. At one side of a quarry in this lot, the uneven character and the thickening of the beds abutting a mass, may be seen. The crest of the reef itself appears a little farther back. Its form evidently is ridge-like. Its position may be traced for eighty-eight paces by an overlying crest of upturned rock edges passing into a ridge of soil, fading out with the increasing depth of the drift. Another reef has been blasted through in forming a roadway from this quarry.

Five other examples, left completely isolated by the removal of rock, were found in a neighboring quarry. One of these has been partially destroyed, leaving only the basal portion; two stand in relief upon basin-shaped pedestals of limestone [Pl. xxxi, Fig. 11]; one, ridge-like and extending in the same direction as the mass of similar shape described above, has been traced thirty-one paces to its disappearance under the embankment of the Falls Branch of the New York Central railroad; one fuses into the quarry floor, which slopes gently from it, a ridge-like rounding of this limestone surface on one side, forming a continuation of the long axis of the reef. This surface shows the configuration of the old sea floor in the vicinity of the reef. The hard, compact structure of this floor is in marked contrast to the loose shaly nature of the weathered reef rock. Another quarry in the vicinity has afforded five more. The electric road from Tonawanda to Lockport cuts through this level, exposing two reefs.

Some of the reefs observed must start almost upon the impure concretionary base of the Lockport limestone, others fifteen to twenty feet higher. The largest is that at Niagara gorge, at the cantilever bridge.

This horizon includes the encrinal band and perhaps the lower portion of the Coralline limestone described by Hall. They may extend still higher. for professor Hall* describes a mass and accompanying arching of the strata, as occurring

Geol. 4th District, N. Y., p. 92.

two miles south of Lockport on the Erie canal. His explanation was that the mass was the result of mineralization. The encrinal band may be traced into western Monroe county before its characteristics entirely fade. No search for reefs has been made in this quarter as yet, and the cursory examination given the outcrops between here and Niagara gorge has failed to reveal others.

Two of the masses west of Lockport have been known to the writer several years, but their nature was not clear until they were observed at Niagara gorge in connection with the reef structures of the Clinton.

Bryozoans form the main constructional element of these old reefs. One of them exposed in the quarry on the eastern bank of the Niagara, a short distance south of the third watchman's hut, is forty-five feet long and nearly a solid mass of fistuliporids. Crinoids are nearly or quite as important in some cases as the Bryozoa. The *favosite* and *heliolite* corals are sometimes important builders.

The peculiar groupings of special forms are as marked a feature here as in the reefs of the Clinton. Some of them are remarkable for their general assemblages, but in most cases at various stages in the growth, or at various points upon these masses and occasionally throughout their entire formation, certain forms predominate or occur in unusual numbers. Sometimes they are corals, delicate branching bryozoans, trilobites or cephalopods.

It is noticeable that a number of species, mainly brachiopods and trilobites, common in the Clinton reefs, nearly one hundred feet lower, are found here.

These masses in the Lockport limestone of western New York find their counterpart in lithological character, fossil contents and stratigraphic position, in the reefs described by Dr. Chamberlin* in the Waukesha and Racine beds of the Wisconsin Niagara. These structures were found to form a barrier reef sixty miles in length. From them two hundred species have been obtained.

Dr. Chamberlin calls attention to a feature which we have already noted in the reefs of New York, viz. a tendency of the life of the period to collect in groups of special forms, which

*Geol. of Wis., vol. i, 1873-1879, pp. 183-186; and Geol. of Wis., vol. ii, (1873-1877), pp. 369-71.

FIG. 4. Beehive-shaped mass, 10 feet high, starting in the upper massive bench, C, of the Clinton upper limestone, and reaching up into the Rochester shale, B, about 8 feet. A, Lockport limestone.

FIG. 5. Same mass as Fig. 4, seen from above.

REEF IN NIAGARA GORGE.

About one-fourth mile above whirlpool.

FIG. 6. REEF IN NIAGARA GORGE.

FIG. 7. Lens in Rochester ravine, 150 yards north of east end of Seneca Park Bridge. Dimensions 14 feet. A—Rochester shale; B—upper bench of Clinton upper limestone.

FIG. 8. Reef in Lockport limestone, Niagara gorge, one-half mile above Suspension bridge, by Electric (Gorge) R. R. Length 110 feet; hight exposed, about 12 feet.

REEF STRUCTURES.

Fig. 9. Mass by highway, 3 miles west of Lockport.

Fig. 10. Reef appearing above the soil in a field in the western edge of Lockport.

Fig. 11. Reef appearing in quarry, north side of N. Y. C. R. R., about one and one-half miles west of Lockport station. Diameter 24 feet.

REEF STRUCTURES IN LOCKPORT LIMESTONE.

reaches its most striking development among these reef forms. This he speaks of as "Colonial Tendencies."†

Dr. Robert Bell‡ has described great cavernous masses of limestone occurring in thin bedded, nearly barren limestone of Devonian age, on the Attawapishkat river, Canada. They are made up of a few species of fossils including corals. These from their form and contents suggest our reefs of the Clinton and Niagara.

Dr. G. K. Gilbert and F. P. Gulliver§ describe the cores of the Tepee Buttes of Colorado, as hard squamous masses of limestone of elongate cylindrical form, resting in the soft shales of the Fort Pierre Cretaceous. The authors are inclined to regard them as formed by colonies of *Lucina occidentalis-ventricosa,* of whose remains they are mainly composed. From their having so many features in common with the masses described by Dr. Bell, they regard their close relationship unquestionable.

A SCHEMATIC STANDARD FOR THE AMERICAN CARBONIFEROUS.

By CHARLES R. KEYES, Des Moines, Iowa.

In the attempts to parallel, in America, the various subdivisions of the Carboniferous, there has always been more or less difficulty in securing results that are even approximately satisfactory. The sections of the East, of the Interior, and of the West, appear at first glance to have no comparable elements. In consequence, the eastern, or Pennsylvania, succession, having been the first to be carefully studied, has come to be regarded as the section to which all others of the continent must be eventually referred. As for the rest of the continent, little consideration is given it so far as concerns any serious effort to establish general sections with which all others in each province might be compared, and which in its serial subdivisions, at least, could be arranged with reference to a schematic section.

One main reason for this rather anomalous state of the subject is, of course, the fact that the boundaries between

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†*Ibid*, pp. 184-196,

‡*Geol. and Nat. Hist. Survey of Canada, Ann. Rept*, vol. ii, (1886), pp. 27G, 28G.

§*Bull. Geol. Soc. Am.*, vol. vi, pp. 333-342, part 17.

the several provinces of the Carboniferous are, as yet, nowhere carefully determined. Separating the exposed areas are broad stretches of country in which practically none of the younger Paleozoics are represented in outcrop. Another consideration is the fact that the formational units established in the various districts, have been largely local in nature and tentative. They are now known to possess widely different taxonomic values, hence permitting only very vague stratigraphical correlations to be carried on. A third feature is one which has been thought by many workers to render all attempts at paralleling horizons useless, and is the diversity of origins which the sediments present. The marine nature of the deposits in one province, as in the Rocky Mountain region for example, and the general presence of littoral conditions at the time the formations were laid down in other regions, as in the Appalachians, would seem to almost preclude comparison.

In the Mississippi valley, however, there are all of the several kinds of conditions of sedimentation well represented, The marine deposits alternate with off-shore and coastal sediments. Not only do the different kinds of formations alternate, but many extensions of those from the west interlock with those from the east. During several distinct epochs the sea encroached upon the domains of the coastal deposits. At other times the coarse land-derived materials were carried far out into areas where more open-sea conditions had previously prevailed. In the general vertical section of the Mississippi valley, or more specifically that of the Ozark region, where is perhaps the best representation of strata, is believed to exist a record that in all respects sufficiently approaches both that of the East and that of the West, to enable it to be made useful in the exact correlation of the serial relations of the Carboniferous of the whole country. The relations of this succession of formations is such that from it, it appears possible to construct the schematic section of the Carboniferous for the entire American continent.

The chief merit of the general Ozark section of the Carboniferous as a standard of reference is its exceptional completeness. No other section of the Carboniferous rocks on the American continent possesses such an enormous thickness.

The series of the system appears to be more sharply defined than anywhere else. Few sections have the base so abruptly cut off from the Devonian below. At the top the Cretaceous strata often rest upon it in marked unconformity.

Instead of trying to make the Mississippi valley section fit that of Pennsylvania, as heretofore has always been done, effort would be far more fruitful of satisfactory results by bringing the rock succession of the latter into accord with the former. In place of attempting to extend the Mississippi sequence to the region of the Rockies, the formations of the latter should be apposed to those of the first mentioned. In other words, a direct and complete reversal of present methods of comparative procedure is recommended as the first step in the solution of the intricate problems of correlation presented.

The critical criteria for bringing the general sections of the various provinces into harmony with a general schematic section for the continent must be very different from those which have been long in use. The fossils have not only failed to give exact results, but it is now known that in many cases their several elements actually admit of no logical camparisons. The comparisons of the floras have been more satisfactory, so far as they have gone, but they have been necessarily limited; and as yet there have been no means of checking these readings.

A review of the work of the last fifty years clearly demonstrates that in correlating strata, the testimony of the fossils does not give the results expected of them. For exact correlation, we must turn to other standards. In the physical history of a region the most hopeful outlook is presented.

In comparing faunas which are marine in one province or region, brackish in another, littoral elsewhere, there are few or no common factors that can be readily utilized. In order that the real significance of the varying features may be understood, the fossils demand vastly more study than can ordinarily be given them in a short time. The sought for information is therefore usually obtained from other sources long before the fossils are able to yield it up. The methods of physical correlation of strata have now become so advanced that the results are highly satisfactory and exact to a remark-

able degree, even between rock successions of different provinces. Even the principle of orotaxial correlation* is found to be so nicely applicable† tnat its wider extension must be productive of results wholly unlooked for.

A general section of the Carboniferous of the Mississippi valley is as follows:

General Geological Section of the Carboniferous of the Mississippi Valley.

	SERIES.	TERRANES.	THICKNESS FT.
CARBONIFEROUS SYSTEM.	*Cimarron*	Kiger shales	250
		Salt Fork shales	500
	Oklahoman	Wellington shales	200
		Marion limestones	150
		Chase limestones	200
		Neosho shales	150
	Missourian	Cottonwood limestone	10
		Atchison shales	500
		Forbes limestones	30
		Platte shales	150
		Plattsmouth limestones	30
		Lawrence shales	300
		Stanton limestones	35
		Parkville shales	100
		Iola limestones	50
		Thayer shales	75
		Bethany limestones	100
	Des Moines	Marais des Cygnes shales	250
		Henrietta limestones	75
		Cherokee shales	300
	Arkansan	Sebastian	1800
		Spadra	500
		Norristown	400
		Boonville	2500
		Appleton	1300
		Danville	2000
		Millstone grit	500
	Mississippian	Kaskaskia	200
		St. Louis	300
		Augusta	250
		Chouteau	100

*American Geologist, vol. xvii, 1896, pp. 289-302.
†*Bull. Geol. Soc. America*, vol. xii, 1901, pp. 173-196.

In the Mississippi valley section, the dividing lines between the several series are horizons which are probably capable of being very much more widely traced than has yet been attempted. Most of the planes separating the series are natural stratigraphic horizons. They are located at levels where marked changes in sedimentation have taken place, where new phases of geological history begin, where lithological differences were brought into strong contrast. Decided orogenic changes of a rather abrupt nature took place at the times represented by these boundary lines of the series.

The subdivisions of the series are of minor importance in the present connection. Whatever might be these values in the Mississippi valley they would necessarily have few or no elements of exact comparison with those of other geological provinces.

The attempts to parallel the Mississippi valley section of the Carboniferous with that of Pennsylvania have been not only uniformly unsatisfactory, but on the whole manifestly more or less fanciful. With the Mississippi section now so well determined, with its subdivision meaning something more than mere convenient groupings of strata, and with the extension of the scheme westward, the Ohio and Pennsylvania sections come to have a significance that was wholly impossible to ascribe to them before. Of course with the present nomenclature and present divisional lines the terranes can be compared only as approximate equivalents.

Graphically represented, the serial terranes of the Carboniferous system have, according to the best information we have, something of the following relationships and developments, shown in the subjoined cut (Fig. 1):

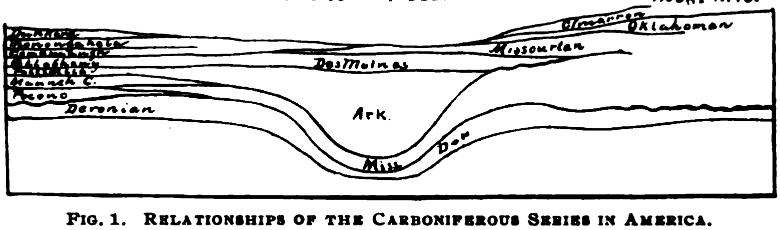

FIG. 1. RELATIONSHIPS OF THE CARBONIFEROUS SERIES IN AMERICA.

In the East and in the West the base of the Carboniferous system appears to be well defined on account of the presence of

marked unconformities. The depositional equivalents of these great erosional breaks in sedimentation have never been suggested or sought for. What they represent in terranes would be of greater interest to know. They may have been formed while very considerable deposits were being laid down as Carboniferous formations. The horizon of unconformity might then be separated from the real base of the Carboniferous by a stratigraphical interval of very considerable extent. As an analogous illustration of what vast possibilities might occur, even in the Carboniferous system itself, the Arkansan series of the Ozark region may be cited.*

In the Mississippi valley there appear to be no indications of the existence of unconformable relationships between the beds called Devonian and those termed Carboniferous. The succession so far as is now known is unbroken and the sediments are of marine origin. For this reason a Devonian facies of the fossils may have been retained in this region long after the Carboniferous was fully inaugurated in other provinces.

The problems which arise for solution in this connection are many; and their definite formulation is of fully as much importance as the recognition of the fact that they exist.

As a terrane, or structural unit the typical Mississippian series can be probably never exactly extended into the eastern provinces or into the western districts. In the first named direction terranes of very different lithological composition replace it. In the second direction there must be for a long time yet difficulty in separating it from lithologically similar formations above, through the whole sequence of which the succession of faunas is unbroken and must change very gradually. Just how much of the Pocono and Maunch Chunk formations of the Pennsylvania section which are commonly regarded as forming the Lower Carboniferous, is the stratigraphic equivalent of the Mississippian must depend upon some further exact work of correlation in the region occupied by Kentucky and Indiana. The same is true, to a less degree, of the Ohio section. At present, it seems probable that a part of the Waverly will be found to belong more properly to the Devonian.

In the east, the Mississippian appears to be replaced by at least two terranes of as yet indeterminable vertical extent

*Bull. Geol. Soc. America, vol. xii, 1901, p. 179.

and wholly different in origin from it. On the other hand, in the west the marine deposits, which must be its equivalent, merge above with the later Carboniferous formations of like origin and lithological character. With no shore representatives in the west between the marine Mississippian and the marine Missourian formations, and the rock sequence being unbroken, the marine facies of the Arkansan and Des Moines are important features for determination.

While westward the littoral formations known in the Mississippi valley as the Arkansan and Des Moines series have no representatives of like origin, their eastward extension is not so difficult to follow. The Arkansan, so enormously thick in the typical locality, thins out rapidly eastward. Although its exact equivalents have not been carefully followed through Kentucky, Indiana and Ohio to Pennsylvania, it seems that it may be regarded as probably representing very nearly the interval occupied by the Pottsville in the last mentioned state. This interpretation has additional weight on account of the fact that all present evidence goes to indicate that the Alleghany series of Pennsylvania and the Des Moines series of the Mississippi valley are about equivalent stratigraphically. The late floral determinations of White* also go to support this statement.

Of the Pennsylvania section the interpretation advanced would make the Conemaugh and the Monongahela, and probably also the Dunkard (so-called Permian) littoral and coastal representatives of the Missourian; for it is not now believed that any part of the so-called Permian in Pennsylvania is so high stratigraphically as the base of the so-called Permian of Kansas.

It is not thought that the Oklahoman has any depositional equivalents in the east. Until recently it was believed that the Cimarron or Red Beds of Kansas would eventually prove to belong to the Triassic or Cretaceous, but late information seems to show that the formation doubtless is a part of the Carboniferous.

*U. S. Geol. Sur., Mon. xxxvii, 1899.

THE TORONTO AND SCARBORO' DRIFT SERIES.

By WARREN UPHAM, St. Paul, Minn.

Among all the North American localities of interglacial deposits, Toronto and Scarboro', situated close together on the northwestern shore of lake Ontario, present questions of the greatest interest and importance in their relation to the changes of climate attending the decline and end of the Ice age. The complex drift series of these localities, including alternate formations of till and fossiliferous freshwater beds, has been described, with discussion of their climatic significance, by Hinde,* Coleman,† Chamberlin,‡ and the present writer.§

It will be needful, therefore, to give in this paper only a general statement of the drift sections and their remains of the Late Glacial fauna and flora. The chief purpose will be to inquire what these imply concerning the conditions that here permitted several alternations of glacial and interglacial beds, and to learn whether they indicate a far retreat of the border of the ice-sheet, worthy to be called a distinct interglacial epoch, or were records of moderate oscillations of the ice border, being then referable wholly to minor stages in the closing Champlain epoch of our continental glaciation.

According to the view presented by Chamberlin, in 1894, the Toronto interglacial beds are referred provisionally to a long interval between the Iowan and Wisconsin stages or epochs, giving to them a large epochal significance. They would thus denote a prolonged time of greatly diminished area of the continental ice-sheet, or its complete disappearance, succeeded by renewed far advance, if not indeed wholly new accumulation, of the vast ice-fields. Hinde, writing much earlier, gave a nearly equivalent opinion; and Coleman,

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*G. J. HINDE, "The Glacial and Interglacial Strata of Scarboro' Heights and other localities near Toronto, Ontario," *Canadian Journal*, vol. xv, pp. 388-413, April, 1877.

†A. P. COLEMAN, "Interglacial Fossils from the Don Valley, Toronto," AMERICAN GEOLOGIST, vol. xiii, pp. 85-95, Feb., 1894; "Glacial and Interglacial Deposits near Toronto," *Journal of Geology*, vol. iii, pp. 622-645, Sept.-Oct., 1895; "Glacial and Interglacial Beds near Toronto," *Jour. of Geol.*, vol. ix, pp. 285-310, May-June, 1901.

‡T. C. CHAMBERLIN, "The Toronto Fossiliferous Beds," in chapters contributed to Prof. James Geikie's Great Ice Age, third edition, 1894, pp. 765-769; "The Classification of American Glacial Deposits," *Jour. of Geol.*, vol. iii, pp. 270-277, April-May, 1895.

§"Climatic Conditions shown by North American Interglacial Deposits," AM. GEOLOGIST, vol. xv, pp. 273-295, with map, May, 1895.

in his subsequent papers, agrees with Chamberlin, though the observations noted seem to be favorable to the opposite view which I suggested partly and imperfectly in 1895, in the paper before cited, and which, by the more ample data since published, I will here endeavor to support more fully.

My interpretation of the history recorded by this drift series in and near to Toronto and Scarboro' refers it to minor climatic vicissitudes during a late part of the Wisconsin or Champlain epoch. Under either view the alternating glacial and interglacial beds belong to the last third, and most probably even to the last tenth, of the Glacial period; and my explanation places them indeed very near to its end, in companionship with the great glacial lakes Agassiz, Warren, Algonquin, and Iroquois.

Details of the sections of this series, and lists of the fossils in its interglacial deposits, have been given by Hinde in 1877, and by Coleman in his several papers of 1894, 1895, and 1901. The last of these papers is based largely on the report of a committee of the British Association for the Advancement of Science, presented at its Bradford meeting, in 1900, by Prof. Coleman as secretary of the committee, with a separate report on the known Pleistocene flora of Canada by Prof. D. P. Penhallow. The mollusca were determined by Dr. William H. Dall, and the insects by Mr. Samuel H. Scudder. The great numbers of species reported far surpass any other locality of fossiliferous interglacial beds in America.

Coleman writes in his latest paper as follows:

WARM CLIMATE BEDS OF THE DON VALLEY.

The earliest beds of the Toronto formation were deposited on the eroded surface of the Iowan till or on the shales which had been laid bare beneath it by river action; and they were formed probably in the shallow waters of a lake, though some features suggest the action of currents. At the bend of the Don, coarse, little rounded shingle of the harder layers of the underlying Hudson River rocks makes the lowest bed visible above the present river, and suggests the action of a current rather than of waves. Thick sheets of vegetable matter, greatly decayed twigs, leaves, reeds, etc., with trunks and branches of trees, are interbedded with the shingle, however, showing that the current could not have been swift. Possibly these beds were formed just at the mouth of a small river like the present Don, where

it entered a lake standing twenty or thirty feet higher than Ontario. If this is correct, there had already been a damming back of the interglacial waters to a higher level than has been reached yet in Postglacial times. This damming could not have been by ice, for the climate was at least as mild as at present, since the tree trunks referred to include wood of the red cedar, an elm, the pawpaw, and three species of oak; and among the shellfish there are two not reported from Canadian waters at the present day, though found in the Mississippi, Quadrula (Unio) pyramidata and Anodonta grandis. * * *

SECTION AT TAYLOR'S BRICKYARD.

		FEET.
8.	Yellow or brown sand with some reddish clay (no fossils)	3-60½
7.	Blue peaty clay with some gray sand (Unios, wood, caribou horn)	4½-57½
6.	Yellow to brown sand with thin layers of purplish clay (shells)	14-53
5.	Fine gray and yellow sand (Unios and other shells)	3-39
4.	Blue stratified clay and sand (Unios, with other shells, and logs of wood), above 2½ feet of boulder clay resting on Hudson River shale	2-36

SECTION AT BEND OF DON.

3.	Brown clay with sandy layers (Unios Campeloma, etc)	5-34
2.	Blue clay with sandy layers (Unios, Anodons, wood)	6-29
1.	Coarse shingle with clay and peaty layers (shells and logs)	4-23
	River Don above lake Ontario	19-19

From the combined section given above it will be seen that the warm climate beds of the Don, commencing 19 feet above lake Ontario, have a total thickness of 41½ feet. * * * The lowest point at which the Unio clays and sands have been found is 41 feet below lake Ontario at the foot of Scarboro' Hights, giving a vertical range of more than 100 feet for the whole series of warm climate beds. * * *

In all there are thirty-nine undoubted species of mollusks, and three more probably, included in the fauna. Of these eight or ten have not been reported from lake Ontario, but occur farther south. [See Prof. Coleman's paper for lists of the species of the fauna and flora.]

Professor Penhallow * * * states that "within this area no less than thirty-eight species [of plants, mostly trees] have been recovered, and they point conclusively to the existence of climatic conditions differing materially from those which now prevail, and of a character more nearly allied to those of the middle United States of today." "Only one species appears to have disappeared in Pleistocene time. Acer pleistocenicum, which was abundant in the region of the Don, bears no well defined resemblance to existing species."

The plant remains consist chiefly of wood and leaves, the former usually much flattened from the pressure of the later ice-sheet, but otherwise often well preserved, the red cedar, for instance, showing

its color and being still quite tough, although some of the wood, probably decayed before being water-logged and included in the clay, is in a worse condition. Parts of the wood are almost of the nature of brown coal, breaking across easily and showing a coaly luster on the broken surfaces. It may be worthy of mention that some large bits of porous charcoal, as if from the burning of a log, were found cemented with limonite in the sand (No. 6) just under the blue clay. The leaves are preserved generally in the thinner body of clay, and are rarely obtained whole. * * *

THE SCARBORO' OR COOL CLIMATE BEDS.

After the close of the Don period, the interglacial lake deepened greatly, finally standing more than 150 feet above lake Ontario, and a great series of clays and sands were deposited by the Laurentian river in the form of delta materials in the wide and deep bay at this time extending still farther to the north than before. As seen at Taylor's brickyard, the clay beds, gray and finely laminated, with a few thin peaty layers, rest conformably on the brown sand at the top of the Don beds. The thickness, however, is not great, on account of later interglacial erosion, at the south end of the clay pit only 7½ feet, 70 yards north, 13 feet, and a quarter of a mile to the northeast, 30 feet. These clays are magnificently shown at Scarboro' Heights, where they were carefully studied by Dr. Hinde. They commence, as shown in a well sunk on the shore beneath the cliff, about five feet below lake Ontario, and rise eighty-five or ninety feet above it. The upper surface mingles somewhat with the overlying sand and varies in hight to some extent. The clay is gray, very firm and resistant, almost as much so as the Hudson River shale of the region, and is generally finely laminated, though there are beds from two to four or five feet thick, showing little or no lamination. Besides the fine lamination there are often thin layers of grayish silt with peaty material at distances of one or two inches apart, perhaps representing flood seasons of an annual character. These silty layers cannot often be traced for more than a few feet horizontally, and may run up or down into a bed showing no lamination in a way suggesting cross bedding. Another very characteristic feature is the presence of half inch sheets of greenish impure siderite every two or three feet, though these are not found everywhere.

The silty layers with peaty substances when washed to remove clay and then dried and looked over with a lens show great uniformity in all parts of the region. Scales of mica are always numerous, as well as mosses, spruce leaves, certain round black seeds, and chitinous portions of beetles. So constant is this assemblage that these clays are easily recognized by it when found in new localities, the clay ironstone sheets affording an additional earmark. Finally these are the only clays in the region which burn to a dark red brick. As their materials must have been derived by the Laurentian river and its tributaries from the calcareous boulder clay of the valley to the north, much of

the lime must have gone into solution by artificial weathering before reaching the river or have been dissolved during the time of transport, thus allowing the red color due to iron to appear on burning. * * *

Dr. S. H. Scudder, who determined the beetles, thinks that all but two of the 72 [species listed in Coleman's paper] are extinct. * * * The number of species of beetles could no doubt be extended if the work of determining them were not so very laborious. In addition to the beetles, cyprids occur, and rarely also fragments of Sphæriums.

The plants include several trees. Prof. Penhallow having found Larix americana, Picea alba, and another species of Picea, in materials from Price's and Simpson's brickyards; while Dr. Macoun found leaves apparently of willow and alder in peaty material from Scarboro', as well as two shrubs, Oxycoccus palustric and Vaccinium uliginosum, and some smaller plants, such as Equisetum, Carex aquatilis, and C. utriculata. Dr. Hinde reports five species of mosses. * * *

Dr. Scudder judges from the relationships of the beetles to modern forms that the climate had "a boreal aspect, though by no means so decidedly boreal as one would anticipate under the circumstances." The same conclusion is reached by Dr. Macoun and by Prof. Penhallow from the plant remains. * * *

The peaty clay occupies the western part of the great bay into which the Laurentian river emptied when the interglacial lake was at its greatest hight. * * * the whole extent of the beds [is probably] 25 miles from east to west. The last exposure known towards the north is 6½ miles inland from lake Ontario, and no doubt if the cuttings of the Don were deep enough it would be found considerably farther north. The greatest thickness of the clay at Scarboro' is about 94 feet, 5 below the lake and 89 above; but the upper limit is rather hard to fix, since it becomes interbedded with sand. * * *

INTERGLACIAL SANDS.

Above the peaty clay at Scarboro' there are stratified sands with a thickness of 55 or 60 feet where best developed near the central part of the Hights, following the lower beds conformably and apparently laid down in shallower water but under similar climatic conditions. The lower 4 or 5 feet have clayey layers, but above this the sand is quite coarse, though free from pebbles, and shows cross bedding in some layers. In the sand are found all the usual minerals of Archean rocks, and a few bands of garnet and magnetite occur, evidently arranged under wave action, as on the present beach at the foot of the cliff. Just over the peaty clay there is sometimes an accumulation of coarse woody material, flattened twigs, bits of bark, etc., with quite large branches of Larix americana and Abies balsamea; and similar layers, but in less quantity, occur at a few points twenty or thirty feet higher up in the cross bedded sand. Near the top of the sand numerous nut-like concretions of brown iron ore are found, and occasionally also a few shells, such as Sphaerium rhomboideum, S. fabale, Limnaea sp., Planorbis sp., and Valvata tricarinata, but Unios have not been ob-

tained from them. The stratified sands were apparently laid down like the clays, from materials brought from the north by the Laurentian river, but in the shallower water where wave action was effective, forming wide sand flats and largely filling the western side of the bay previously described.

A series of interglacial sands and gravels occurs in western Toronto, and is well exposed in large pits near Christie and Shaw streets; but its exact relation to the Scarboro' deposits is not certain. Where the two series meet near the corner of Dupont and Bathurst streets there are two or three beds of clay with peaty layers interstratified with sand, suggesting that the sand and gravel are of the same age as the Scarboro' clay.

The sand and gravel beds have a thickness of at least 78 feet, and rise 130 or 140 feet above lake Ontario, but their extent is unknown, as they are in general buried under boulder clay. It is certain that these beds were formed under different conditions from those either of the Don or Scarboro'. They are of coarser and more variable materials, often showing very marked cross bedding, probably produced by currents rather than waves, and sometimes apparent unconformities such as are made by a stream changing its bed. We may suppose that an interglacial Humber river coming in from the west or northwest, brought down sand and gravel at the edge of the great bay, mingling them at some points with the clayey delta materials of the Laurentian river.

This brings to a close the series of deposits forming the Toronto formation. In all there are four varieties, the sands and clays of the Don, with their warm climate trees and Mississippi Unios; the peaty clays of Scarboro', with their seventy distinct beetles and their small flora, suggesting a cool but not arctic climate; the stratified sands overlying them, probably forming a continuation of the cool climate period; and the western sands and gravels, with elephants, bisons, and some shell-fish, affording little evidence as to climate. The maximum thickness observed in each set of deposits is as follows:

3. Scarboro' sands ....60 feet.		4. Western sands and gravels........78 feet.
2. Scarboro' peaty clays.....94 feet.		
1. Don beds................41½ feet.		
195½ feet.		

These Toronto and Scarboro' interglacial deposits, after being spread as a vast composite delta plain, with gentle lakeward slope, were deeply channeled by several streams before the ensuing glaciation covered the whole with alternating sheets of till and modified drift. On the present shore these valleys, partially filled by the later drift, descend below the level of lake Ontario, showing that after the delta accumulation this part of the lake held for some time a lower level than now.

Subsequently a snowy climate again caused an ice-sheet to overspread this area, with repeated oscillations of its border. The oncoming and wavering of this glaciation, shown by its drift series, have also been described by Coleman as follows:

The halt at the Scarboro' delta was long. and must have included at least three great oscillations of retreat and advance, to account for the complex of tills separated by stratified materials now crowning the hights. The first sheet of till is shown for about nine miles continuously at Scarboro' with the shape of a slightly bent bow, touching the lake at each end, and with a sharp downward dip at the Dutch church. The latter is however, less symmetrically placed than in a bow, being only three miles from the west end and six from the east. The hollow of the Dutch church valley was filled with till containing comparatively few stones to a level 50 or 60 feet above the present lake, then merging into gray stratified clay which rises to a hight of 165 feet, where it is covered with a few feet of much later Iroquois beach gravel. Very similar clays rising to the same hight, or a little higher, are found at brickyards to the north of Toronto. They burn to a gray brick, and so are easily distinguished from the peaty clay which makes red brick.

The highest part of the Scarboro' escarpment, about a mile east of the Dutch church, gives the best section of these complex glacial deposits. At the point where the old Iroquois beach is cut off for a distance by the present lake cliff, there is a face of 270 feet displaying three layers of boulder clay separated by stratified sand, the whole overlying the stratified fossiliferous sands of the Toronto formation. A few hundred yards to the east of this the escarpment reaches its highest level, 354 feet above the lake, but the lower part is not so well shown. The upper portion is, however, more complete, since overlying the third till sheet one finds laminated grayish blue or purplish clay followed by evenly bedded fine sand, on which rests a fourth boulder clay. Putting the two sections together, we have the following complete section:

	FEET.	
Boulder clay, No 4	48-354	203 feet, Glacial complex.
Stratified sand overlying stratified clay	36-306	
Boulder clay, No. 3.	32-270	
Silty sand, the upper layers crumpled	25-238	
Boulder clay, No. 2	9-213	
Cross bedded sand	29-204	
Boulder clay, No. 1	24-175	
Fossiliferous sand	59-151	151 feet, Toronto formation.
Peaty clay	92- 92	
Lake Ontario	0	

No fossils have been found in the sands or clays of the glacial complex at Scarboro', but a few have been picked up in stratified sand lying between two beds of boulder clay at the Metropolitan power

house, a mile or two north of Toronto. Amnicola limosa, a Succinea, and fragments of another species. These occur at 220 feet above the lake, but the sand containing them runs up to 247 feet and may correspond to the silty sand between till No. 2 and till No. 3 at Scarboro'.

One of the recessions of the ice, perhaps the one just mentioned, appears to have been very extensive, for two thick beds of boulder clay are found to be separated by stratified materials at numerous points on the lake shore as far east as Newtonville, fifty miles from Toronto. The same relationship is found near the head-waters of the Don, about eight miles north of the city, and also in ravines to the east, but has not been observed to the immediate west; though the stratified clays lying between two layers of till at Dundas and at several points near Niagara Falls may correspond to the same interglacial stage. In that case the ice must have withdrawn eighty miles in a northeasterly direction before advancing again.

* * * The highest boulder clay has not yet been traced with certainty west or south of the Toronto region, however, since the four sheets of boulder clay are very much alike and cannot be discriminated when found alone; and there is a possibility that it ends here, and that the water then filling the Ontario basin was continuous with that of some of the successors of lake Warren.

In several earlier papers, treating of the causes of the Ice age, I have attributed the snow and ice accumulation to great uplifts of the land areas which were glaciated, giving to them a cool and snowy climate throughout the year. From the depths to which preglacial land valleys are now submerged beneath the sea level on the coasts of North America and Europe, it is known that the elevation of the glaciated portions of these continents was 3,000 to 5,000 feet higher than now.

After a very long duration of the somewhat fluctuating ice-sheet on each of these continents, the glaciated areas sank to their present hight or mostly somewhat lower, so that when the ice melted away the sea covered coastal portions of the drift-bearing countries. The great change of climate resulting along the borders of the ice-sheet on account of the land depression caused rapid melting there, and this advanced inland until all the ice disappeared. The depression from the former high altitude, as was remarked by Dana, would transfer the southern part of the ice-sheet from a climate like that of Greenland to the temperate climate of southern Canada and the northern United States. Marginal melting then gradually pushed back the boundary of the ice and thus gave to

its front an increased steepness of slope, whereby any slight halt or readvance due to a series of years of unusual cold and snow-fall became recorded in a marginal moraine.

The predominantly wasting ice border rose probably to an altitude of 5,000 feet within a hundred miles from its edge while being dissolved by the warm Champlain climate with somewhat lower altitude of the land than now. If the retreat of the ice-sheet from the northern United States and Canada occupied, as I think, some three to five thousand years, disappearing earliest from the upper Missouri and Mississippi basins, and latest from New England, the province of Quebec, and Labrador, the extension of a warm temperate flora and fauna could well keep pace with the glacial recession, so that, as on the waning Malaspina ice-sheet, a flora like that of the same latitude today, and concomitant temperate molluscan and insect life, may well have thrived up to the very boundary of the ice, or perhaps in the case of the plants and insects even extending, as in Alaska, upon the drift-covered ice-border.

Darwin noted, in his narrative of the voyage of the *Beagle*, that glaciers in the fjords of southern Chile reach down to the sea level within nine degrees of latitude from where palms flourish. Professor W. O. Crosby tells me of his observations of fine orchards of cherries and other fruits cultivated close to the limits of the large local fields of ice and névé in Norway, one of which has an area of about five hundred square miles. In the Alps the glaciers end only a few hundred feet from productive fields and gardens of flowers. Still more like the condition of North America and Europe during the recession of their Pleistocene ice-sheets is the vast fertile plain of India, enjoying a tropical climate, while within a short distance along its northern side, and farther west and east for an extent of 1,500 miles, runs the almost impassable Himalayan range with valleys bearing glaciers and summits crowned with perpetual snow.

The proximity of the very cold Himalayas does not bring frosts to the neighboring tropical plain. In like manner the ice-sheet still lingering on northern Ontario, New York, and New England, probably did not cause a very frigid climate to prevail in the winters, nor nights of frost in the summers,

on the windward low region of the Laurentian lakes whence the ice had recently retreated.

The thick stratified clay and sand beds forming the lower half of the Scarboro' section were evidently amassed as a delta or broad alluvial slope, perhaps wholly above the water level in the Ontario basin. So large a supply of sediments seems referable to their derivation partly from englacial drift exposed by ablation on the margin of ice-fields within the drainage area of the delta-forming streams. In this tract of confluence between the great eastern and central lobes of the Laurentide ice-sheet, represented by the angle of the drift boundary at Salamanca in southwestern New York, there undoubtedly was brought an exceptional volume of the englacial drift by the confluent glacial currents. Much of these clays and sands may therefore have come from englacial and finally superglacial drift of the neighboring ice-sheet on the northeast, being brought by streams from its melting; while the driftwood and leaves of trees, and mosses of peat bogs, growing within a few miles westward, were contributed to the same deltas by streams flowing from a wooded land area bordering the ice, such as Russell found adjoining the Malaspina ice-sheet in Alaska and even extending its forest growth several miles upon the drift-covered margin of the departing ice.

When the delta, with its fanlike lakeward slope, had attained the maximum depth of nearly 200 feet in the Scarboro' section, lying partly beneath the present lake level, it was deeply channeled by the principal streams, which no longer carried so abundant silt for deposition on that outer part of the delta area.

Later a moderate readvance of the ice-sheet seems to have brought much englacial till, boulder clay, over this district, to be deposited when that thin ice margin melted away; and upon this till the streams flowing from the ice front spread a thickness of twenty-nine feet of cross bedded sand. With the oscillations of small extent and short duration which the ice border often made during its accumulation of marginal moraines, the same alternations of boulder clay and sand were repeated until four distinct deposits of till and three of intervening sand beds, marking four ice advances and reces-

sions, crowned the ridge of Scarboro' Heights, attaining together the thickness of 203 feet.

Several species of the molluscan fauna which earliest came into the region of Toronto, following the retreat of the ice, were later unable to survive, when brought more fully into competition with the eastern fauna of the coastal region; but they are still living farther south and west, within the Mississippi drainage area. It is also especially noteworthy that the very rapid evolution now in progress producing the exceedingly abundant species of insects is shown by the changes, or less probably the extinction, of nearly all the species of beetles found in the Scarboro' delta deposits.

If all this history was subsequent to the beginning of the erosion of the Niagara river gorge, and previous to the rise of this western part of the glacial lake Iroquois, occasioned by the uplifting of the country including its outlet at the east, to form the upper Iroquois beach of Toronto and its vicinity, which I think probable, only a few hundred years, or perhaps a thousand years, more or less, must have sufficed for the deposition of the Toronto and Scarboro' interglacial and glacial series. This conclusion seems well consistent with the apparent evidences of seasonal changes, as if marking years, which Coleman mentions as frequent in the Scarboro' peaty clays.

EDITORIAL COMMENT.

ANNOUNCEMENT OF THE THEORY OF EVOLUTION.

There is no more notable event in the history of science than the joint presentation before the Linnean Society in 1858 of papers by Charles Darwin and Alfred Wallace announcing the theory of evolution by natural selection. Darwin, as is generally known, was most careful in his methods of work. His theory in regard to the transmutation of species by natural selection was slowly thought out from the time of the voyage of the *Beagle,* and was put in writing in 1844. This manu-

script was shortly afterwards shown to Sir Joseph Hooker and others; but Darwin continued to collect facts and to postpone publication. In 1858 Wallace sent him from the East Indies a letter not specifically intended for publicaiton, announcing the same theory of natural selection. Darwin was at first inclined to publish Wallace's paper by itself, but was persuaded by Sir Charles Lyall and Sir Joseph Hooker to have read before the Linnean Society at the same time as Wallace's paper an extract from his unpublished manuscript of 1844 and a letter addressed to Asa Gray. The papers by Darwin and Wallace and a statement by Lyell and Hooker were read before the Linnean Society in 1858 and subsequently published in the Journal of the Society. These documents, to which attention is called by their reproduction in the November number of *The Popular Science Monthly,* are of very great interest both in themselves and in comparison with the full presentation of the theory of evolution by natural selection published later by Darwin and Wallace.

THE AMERICAN PHILOSOPHICAL SOCIETY.

The American Philosophical Society, Philadelphia, founded in 1743 through the instigation of Benjamin Franklin, is the oldest scientific society in America, and ranks among the oldest in the world. Its publications are found in the principal libraries of this country and of Europe. Its membership embraces many of the most prominent scientists of America, and represents the extended national basis on which the society is founded. Arrangements are being made by a committee of the society to enlarge the facilities "for promoting useful knowledge" to which the organization is devoted by the terms of its first circular issued by Franklin, and for widening the plan of publication. It is proposed to hold, in addition to the usual semi-monthly, an annual general meeting designed to attract members of the society from all parts of the country. Papers read at this annual meeting will be of a more general scientific character, and their prompt publication will enable the society to be the avenue of announcement of important results of more extended research. The first annual meeting is to be held Easter week, 1902. This plan, if its results are

commensurate with the expectations of the society, will not only give an auspicious opening for the twentieth century, but will serve to promote the society and the interests for the advancement of which it was established. The career of this society has been an honor to America. The next century promises to rank well with the last. N. H. W.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Geology of the Eastern Choctaw Coal Field; by J. A. TAFF and G. I. ADAMS. (U. S. Geolog. Surv., 20th Ann. Rept., Pt. II, pp. 257-311, 1901).

To those interested in the American Carboniferous every new contribution to our knowledge of the Ouichita district is of the greatest interest. One reason is the enormous thickness of the Carboniferous section that is said to prevail in this district. The eastern Choctaw coal field is in the eastern part of Indian Territory, and extends southward from the Arkansas river. It therefore lies in a region from which may be expected much critical evidence bearing upon the most important part of Carboniferous history on this continent.

No district in this country is more instructive as regards topography than that in which the Choctaw field is situated. A well defined lowland plain is one of the most notable features of the relief. Out of it rise the isolated mountains. "These low-level broadened valleys lying between the mountains grade insensibly northward into the greater valley of the Arkansas. The streams of the lowland are corroding their channels very little, and in general are sluggish and are bordered by wide flood-plains which are very little below the general surface of the lowland plain." A highland plain is also in evidence. "A great number of ridges, hills, and nearly level highlands rise from the lowland plain to elevations of nearly 800 feet above sea-level. These crests, therefore, lie practically in a horizontal plane which is considered to have been the general level of the country in recent geological times. The valleys of the streams lie below it, and above it rise the residuals of the mountains, among which the Arkansas river drainage flows. A few of these mountains have elevations approximating the high levels attained by the principal ridges of the Ouichita mountains and the Ozark plateau."

The mountains of the Choctaw region are all of the same type and have similar detail of surface features. They are all of synclinal structure, and the same formations occur in all four of the mountains in this field and in nearly the same relative position. The sides of the mountains, knobs, peaks, or ridges have the bench and terrace type of sculpture.

The geological structure, stratigraphy and economic features are clearly described. Regarding the distribution of the coal seams of the district it is stated that "Seven workable beds of coal are known in the eastern Choctaw coal field. They occur in four different formations, from the top of the Hartshorne sandstone, which is the lowest coal-bearing rock known in Indian Territory, upward to the lower part of the Boggy shale. The thickness of the rock between the lowest and highest of these coals is estimated to be nearly 3,600 feet. Besides these coal beds, which are profitably worked, there are a number of others that are thin and have been located, chiefly by prospect drill, in various parts of the McAlester shale and Savanna sandstone.

"A knowledge of the geological structure of the rocks in which coal beds occur and of the combined effects of structure and erosion on the topography or surface configuration of the land is necessary to the most successful economic prospecting and exploitation of the coal. Except to test the thickness and quality of a particular coal bed, the drill need not be called into use in a coal field of this nature. All the known coal beds are associated with sandstone beds of considerable persistency, which make their presence and location known by more or less elevated hills and ridges. When the interval between such sandstone and coal beds is once established, the crop of the coal may be located as rapidly as the sandstone ridge or outcrop can be traversed. The dip of the sandstone may be determined at almost any point by measurements on its outcropping edges. The coal beds, on the contrary, usually lying in shale, have their edges worn down and concealed by soil and rock debris."

Good maps accompany the memoir. Also a few paragraphs on the composition and adaptability of the coals. C. R. K.

Geology and water resources of Nez Perce county, Idaho. I. C. RUSSELL. (U. S. Geol. Sur., Water supply papers, Nos. 53 and 54, 1901).

This document is more than a treatise on the water supply and irrigation of Nez Perce county, for it enters largely into the interesting geology of the region, and presents some very fine plates showing the cañons eroded by the streams.

Prof. Russell notes two sharply defined rock groups—a pre-Tertiary and a Tertiary. The former embraces a large variety of rocks of both igneous and sedimentary origin, and large areas of metamorphic rocks. These are disturbed by folding and otherwise and once formed a land surface that was deeply denuded before the younger group was spread upon it. The Tertiary group consists largely of igneous rock, either basalt or volcanic tuffs, but

occasionally it has layers of clay, lignite, sand and gravel. It is nearly horizontal. The older group carries some gold and ores of other metals, but on decay forms a very poor soil. The younger is without native metals and ores but forms a deep dark soil of marvelous fertility. Possibilities of artesian water inhere only in the younger group. The age of the pre-Tertiary group is, in part at least, probably Mesozoic, this being indicated by fossils found in certain limestones. The younger group is Tertiary, as shown by fossils found associated with some of the sedimentary beds lying between basalt sheets.

Prof. Russell judges that in southern and central Idaho, in the Glacial epoch, there were only isolated Alpine glaciers, and no general or continental ice-sheet. These Alpine glaciers produced one of the most marked of the drift phenomena of Idaho, viz. the overwash gravels. The great lava plain is called the "Columbia River lava." Through it protrude many isolated peaks or islands of the pre-Tertiary rocks. These are dominated, generically, *steptoes,* a name derived from Steptoe butte, near Garfield, in Washington. The largest of these known is Eagle Creek range, or Powder River mountains, in Oregon, which, as stated by Lindgren, consists of bare ragged peaks that rise several thousand feet above the basaltic plateau, surrounding them on all sides. This steptoe has a diameter of twenty-four miles.

The Columbia River lava is the most remarkable feature of the geology of the region. It is almost entirely within the drainage area of the Columbia river, covering nearly the whole of Washington and Oregon east of the crest of the Cascade mountains, and extends into Idaho to the Cœur d'Alene and Bitterroot mountains. Its whole area is estimated at 200,000 or 250,000 square miles, its greatest known thickness being 4,000 feet. Following is Prof. Russell's terse description:

"The lava was outpoured at successive intervals, embracing a long period of time, as is shown by the occurrence, at several horizons, of layers of sedimentary material, principally clays and sands, between the lava sheets. In places also the lava sheets are separated by layers of volcanic dust containing the silicified trunks of trees which grew on a soil formed by the decay of the underlying layer, thus showing that the intervals between the flows were in some cases a century or more in duration. The lava came through fissures in the earth's crust--in what are known as fissure eruptions—and spread widely over the land, from which it is evident that each sheet was spread out horizontally. The movements that have occurred in the layers since they cooled and hardened, and which have caused them to be deformed from their original horizontal position, can be studied in the same way as the structure of sedimentary beds. Although the lava sheets are still essentially horizontal over broad areas, they frequently have gentle dips, and in certain regions are tilted and even sharply folded and faulted. On the eastern slope of

the Cascade mountains the lava sheets occur with a dip to the eastward, for long distances, of three or four degrees, showing that a large part of that range has been elevated to a hight of at least 6,000 feet since the lava was poured out. Similar but less extensive deformations have also occurred on the eastern side of the lava-covered country, as will be described further on. Between these bordering areas is the region of the great plains of the Columbia, and southward from it, in Oregon, the lava sheets have, in general, been but little disturbed from their original horizontal position, although a subsidence of three or four thousand feet has probably taken place. Extensive movements in the earth's crust occurred also at certain periods during the time the lava sheets were being formed, as is shown near Clealum, Washington, on the eastern slope of the Cascades, where the upturned and eroded lower portion of the formation is overlain unconformably by later sheets. How widely extended this unconformity may be remains to be determined."

As determined by Mr. Diller this lava consists of plagioclase, augite, olivine and magnetite, with considerable globulitic base.

N. H. W.

Geological Survey of Canada. Annual Report. New Series, Volume XI, 1898. GEORGE M. DAWSON, Director. Parts A, D. F, G, J, L, M, R, and S; together 856 pages, plus 30 pages in Table of Contents and Index; with numerous plates, and four folded maps. Price, 80 cents. Ottawa, 1901.

The summary report of the Director fills 208 pages, narrating the progress of the several departments of the Survey during the year 1898, with outlines of work by field parties, and brief statements of some of their observations and discoveries. Four maps on the scale of eight miles to an inch were completed and printed, comprising an aggregate of about 125,000 square miles. Ten maps on larger scales were also published, seven of these being maps of gold mining districts. The number of visitors to the Museum during the year was 33,183, being more than in any previous year. The entire staff employed in the Survey numbered forty-eight; and the legislative appropriations for it amounted to $107,600.

The second part (D) of this volume is a report, in 44 pages, by Mr. James McEvoy, on the geology and resources of the country traversed by the Yellow Head Pass route from Edmonton to Tête Jaune Cache, on the Fraser river, comprising portions of Alberta and British Columbia. The rock formations, beneath the drift, are of Tertiary, Cretaceous Devono-Carboniferous, Cambrian, and Archean age.

Mr. A. B. Dowling describes, in the third report (F), of 100 pages, the geology of the west shore and islands of lake Winnipeg. The area of this lake is stated as 9,414 square miles, being 2,150 more than lake Ontario; but it is comparatively shallow, as its maximum recorded sounding is 96 ft. The rock series belongs to the Cambro-Silurian system. It consists of the Winnipeg sandstone and shales, about 100 feet thick, probably of Black River age; the Trenton formations, a lower

mottled limestone, about 70 feet thick; the Cat Head limestone, also about 70 feet, and an upper mottled limestone about 100 feet; and the Stony Mountain limestone and shales, probably of the Utica age, 110 feet. The boulder clay, or till, attains a maximum thickness of nearly 100 feet; and on some of the islands and shores it forms low drumlin ridges, running southward, parallel with the course in which the ice-sheet flowed.

The next part (G), in 98 pages, is a report on the east shore of this lake Winnipeg, with adjacent districts of Manitoba and Kewatin compiled by Mr. Dowling from notes and surveys by Mr. J. Burr Tyrrel. This side is in marked contrast to the west, as the rocks are wholly Archean, the preponderance of gneisses and granites of the Laurentian being the chief feature. There are also large areas of stratified clay and silt, deposited in the glacial lake Agassiz, having a rich soil, covered with poplar and spruce forests.

Dr. R. W. Ells reports, in 70 pages (J), on the geology of the Three Rivers map sheet, which is the northwestern sheet of the "Eastern Townships" of Quebec. It comprises nearly 7,000 square miles, mostly yet unsettled, with no means of communication excepting by canoe and portage routes. The rock formation range from the Silurian to the Archean. Pleistocene marine shore lines are stated by Chalmers to occur up to hights of about 500 to 900 feet, showing differential postglacial elevation of the land, the maximum slopes of the highest beaches being about two feet to the mile, rising from east to west.

An exploration of a part of the south shore of Hudson strait and of Ungava bay is reported by Mr. A. P. Low, in 47 pages (L); and a similar report on the northern side of Hudson strait is supplied in Part M, 38 pages, by Dr. Robert Bell. These reports are accompanied by a map, on the scale of 25miles to an inch, colored to show the rock formations along these coasts.

Dr. G. C. Hoffmann, chemist and mineralogist to the Survey, reports his work for the year in Part R, 55 pages; and the Scection of Mineral Statistics and Mines in charge of Mr. E. D. Ingall, is reported in Part S, 196 pages. The total value of metallic products was $21,-705,854, being eight times greater than in 1888, ten years earlier; and of non-metallic products, $38,661,000, being thrice greater than ten years before.

W. U.

Contributions to Mineralogy and Petrography, Sheffield Scientific School. Edited by S. L. PENFIELD and L. V. PIRSSON. Octavo, pp. 482. New York. Charles Scribner's Sons. 1901.

This volume is composed, essentially of reprints of papers by Brush, the two Danas, Penfield and Pirsson, professors at Yale college, and by numerous young men who have been associates at that institution, viz. Hawes, Wells, Allen, Comstock, Harper, Meyer, Farrington, Pratt, Howe, Minor, Foote, Warren, Ford, Weed and Gregory. It also contains a sketch of the progressive development of mineralogy and petrography at Yale, complete bibliographies of the papers

emanating from Yale, and occasional comments and footnotes by the editors intended to elucidate the corrections and discrepancies which lapse of time has rendered apparent. The work issues and is edited from New Haven, is published by firms in New York and London, and is printed at Cambridge, Mass., a fact that indicates not only the cosmopolitan spirit in which it is published, but the cordiality existing between the old university towns of New England.

Probably no greater service could be rendered to American mineralogy and petrography than that which is served by this publication. By all odds Yale has been the American head center of these sciences, and this volume will serve to perpetuate that leadership. These papers are gathered mainly from the American Journal of Science, the earliest being that of Brush, published in 1849, but some are from other sources. The volume is one of a series that have been prepared by the professors to commemorate the bicentennial of Yale university, dedicated to "The Graduates of the University."

N. H. W.

Dragons of the Air. H. G. SEELEY. Methuen & Co., London, and D. Appleton and Company, New York, 1901. 12 mo. pp. 240, with eighty illustrations. Price $1.20.

This little work, which is small only in respect of material bulk, treats of one of the curious traits, one might almost say freaks, of the animal kingdom, viz. that of extinct flying reptiles. It has several plates showing the grotesque forms of the ornithosaurs, both in flying action and in repose on the earth, or walking. There is an opening chapter which is both mythological and anatomical, treating of all animals that fly or that have been believed to fly, fishes, frogs, lizards, birds, and mammals, including man. The volume is historico-scientifico-popular, very interesting and instructive, and should be in the library of every teaching geologist. N. H. W.

Preliminary report on the Copper-bearing rocks of Douglas county, Wisconsin, containing a preliminary report on the copper-bearing rocks of parts of Washburn and Bayfield counties. U. S. GRANT. (Wisconsin Geological Survey, Bulletin No. 6. second edition, 1901.)

Dr. Grant has given two vacation seasons to the field work on which this report is based. He has described in much more detail the same structure and field facts, and reaches, in the main, the same results as were announced in the Wisconsin reports, published in the seventies. In two important respects, however, he differs from those reports, viz. (1) He is not so sanguine of the existence of copper of economic value in northern Wisconsin as was Irving, and (2) he describes as a fault plane the breccia and the attendant features that mark the contact of the lake Superior sandstone on the trap all along the north side of the Douglas range, making it the probable western duplication or extension of the fault plane seen along the south side of Keweenaw point in Michigan.

This fault was formed after the deposition of the lake Superior standstone and the effect on the traps was extensive and remarkable. They are brecciated and reduced to extreme fineness sometimes for a distance of 400 feet from the fault plane but the sandstone, which lies on the north side and which has suffered a great down-throw, is rather thrown into a series of folds, or is broken into large faulted blocks, bending upward, even at sixty degrees from the horizon, at the fault plane.

It might have been well had Dr. Grant given some of the evidence of the long erosion interval which he alludes to as one of the steps in the geological history of Douglas county, said to have occurred between the sedimentary beds of the upper Keweenawan and the lake Superior sandstone. This is a mooted question. Evidently no proof of such erosion interval occurs within the field reported on, else it would have been mentioned. This erosion interval, however, was one of the tenets of the older Wisconsin survey and it seems to have been adopted by Dr. Grant without question. In a preliminary and subordinate report, however, devoted largely to economic facts, and to the description of the field geology, it would have been impossible to have gone into a theoretical question of that nature. In the writer's opinion there was no such erosion interval, but instead there was a progressive subsidence in the lake Superior region, followed later by flexure, faulting, and elevation above the sea. N. H. W.

An investigation of the buried valley of Wyoming.. WILLIAM GRIFFITH. (Read before the Wyoming Historical and Geological Society. Jan. 11, 1901. Wilkesbarre, Pa.)

This old valley has long been known. It has been he cause of difficulty and some fatalities in the mining of the coal at Wilkesbarre. It is filled with gravel and sand, and other coarser drift, to the depth of 200 or 300 feet. If this filling could be removed there would be seen a lake eighteen miles long and a mile in width through which the Susquehanna river would flow. This river now flows along the surface of the gravel bed, but slightly impinging upon the rock rim. It is evident that this gravel is permeated by water for sometimes in mining operations both gravel and water rush into the mines that pass into the limits of the gorge. This gorge is an interesting example of the condition of the surface of the country previous to the drift age.

N. H. W.

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CORRESPONDENCE.

HEAVY RAINS AND POSSIBLE VOLCANIC ACTION IN NICARAGUA.—Rain has fallen in western Nicaragua for one to three hours each day, during the past eighty days; most frequently they have been torrental rains, flooding the streets in the cities of Granada and Managua eight to ten inches deep and rushing in rapid currents into the lakes Nicaragua and Managua.

The result is that the water in these lakes is now for this season of the year several feet higher than remembered by reliable citizens to have been since the high water in 1859-61.

Because of the unusually large rainfall thus far, this year, it is quite probable that next December and January [usual high-water months annually in the lakes above named] the water in lakes Nicaragua and Managua, will be more than two feet higher than the remembered by reliable natives, high-water years 1859-61, when they were about ten feet higher [so reliable people have declared to me] than when measured by the engineer corps of the Isthmean Canal Commission 1898-99-1900.

There appears to be a periodic time of about forty years of unusually high water—far above the usual hight. I am endeavoring to ascertain if there are not records, in the archives of the old Roman Catholic churches, some of them established in Nicaragua before A. D. 1600, of unusually high-water in these lakes—but it will probably take months of search among the confused mass of papers in each church before ascertaining whether such records exist.

What effect the pressure of this unknown stage of water will have in, say next October, November and December, on the semi-slumbering to apparently nearly extinict volcanoes in and near them, is looked forward to by me with much interest, because, from more than fifteen years of observations and studies of volcanic masses in the tropical Americas, I have formed the opinion that the varying pressure of water in and above the numerous fissures is most frequently the cause of volcanic activity. The fissures referred to are observable for hundreds of feet from the base of the volcano when the water surrounding it, or adjacent to it, is at a low stage, or traceable for miles in the earth near its surface when the volcano is not surrounded by, nor adjacent to, a large volume of water. These fissures are the escape, or safety valves. of apparently slumbering volcanoes, permitting high tension gases to escape as they near an exploding condition, except when the pressure of water in the lakes and bays surrounding or in part surrounding the volcanic mass becomes so great as to repress them. These gases are under pressure from the superheated magma formed miles down beneath the earth's surface. J. CRAWFORD.

Managua, Nicaragua, August 31st, 1901.

Second edition of the Geological map of West Virginia.—The new geological map of West Virginia first published under date of

January 10th, 1899, by the West Virginia Geological Survey, has recently been revised, new features added and republished under date of August 1st, 1901.

The map shows in separate colors the three great coal formations of West Virginia, viz.: the New River of Pocahontas, the lowest, the Allegheny-Kanawha series in the middle, and the Monongahela or Pittsburg (Connellsville) at the top. Two features not shown on the original map have been added in this edition, viz.: the prominent anticlinal lines, and the locations and names of every coal mine in the state shipping coal by rail or river, up to July 15th, 1901, the approximate locations of the mines being indicated by numbered black dots, and the corresponding names and numbers printed on the margin of the map by counties.

The State Geological Commission has placed this map on sale at the office of the survey at the price of 50 cents per copy from which there is no discount.

The map shows the coal, oil and gas developments of the state at a glance, and should prove of much use to every one interested in these subjects, even though the topographic base of the map is unavoidably very inaccurate, and must remain so until the topographic map now being constructed by the coöperation of the State and United States Geological survey shall have been completed five to six years hence.

Those who desire it should fill out the accompanying blank and enclose it with 50 cents to the office of the West Virginia Geological Survey, Box 448, Morgantown, W. Va.

I. C. WHITE.

September 20th, 1901. State Geologist.

NEW YORK ACADEMY OF SCIENCES. The first meeting of the Section of Geology and Mineralogy of the New York Academy of Sciences was held on October 21. In calling the meeting to order the chairman spoke of the loss to the Academy and to science occasioned by the death of Dr. T. G. White, secretary of the Section, and of professor Joseph LeConte, corresponding member of the Academy. A committee consisting of professors J. J. Stevenson and J. F. Kemp, was appointed to draw up suitable minutes in reference to Dr. White and professor LeConte.

Dr. E. O. Hovey, of the American Museum of Natural History, was then elected secretary of the Section.

The following program was then offered:

A. W. Grabau spoke on *Recent Contributions to the Problem of Niagara.* He said that Davis has shown that the topography of the Niagara region conforms to the type generally found in ancient coastal plains, the original features of which have been more or less modified by subsequent warpings, and by glacial erosion and deposition.

The Niagara escarpment is the inface of the Niagara cuesta, traceable through the Indian peninsula and Grand Manitoulin island. The Ontario lowland is continued in the Georgian Bay lowland. A second cuesta—the Onondaga—has its inface slightly developed north of Buffalo, but becomes prominent in the Lake Huron valley, where its in-

ner lowland forms the deeper part of the lake. The third cuesta and lowland (the Erie) occurs north of the second.

The Tertiary drainage is supposed to have been to the southwest, instead of the northeast as Spencer holds. The principal streams of that time are supposed to have been, (1) the Saginaw—whose path is indicated in part by Saginaw bay and the deep channel between the Indian peninsula and Grand Manitoulin island, (2) the Dundas, breaching the Niagara cuesta at Hamilton, Ont., and crossing the Erie lowland near Fort Stanley, and (3) for a time, at least, the Genesee, though this may later have had a northward course. The subsequent streams tributary to these consequents, carved the various lowlands. St. David's channel is regarded as an obsequent stream, which was accidently discovered by the Niagara. The whirlpool gorge was probably, in part, the southward continuation of this stream, and not wholly postglacial.

Professor J. F. Kemp's first paper was on the *New Asbestos Region in Northern Vermont.* He said that asbestos has recently opened up on a commercial scale in the towns of Eden, Lamoille Co., and Lowell, Orleans Co., Vt. The towns are adjacent, although in different counties. The asbestos lies from fifteen to twenty-five miles north of Hyde Park, a station on the St. Johnsbury and Lake Champlain R. R. As is quite invariably the case, it occurs in serpentine, either in veins, or in matted aggregates along slickensided blocks. The serpentine where the best fibre is found lies on the south shoulder of Belvedere mountain, and forms an east and west belt. It is bounded on the north and west by hornblende-schist, which forms the summit of the mountain. The contact on the west is a visibly faulted one, and that on the north is probably also of the same sort, because the hornblende-schist rises in a steep escarpment.

The serpentine seems to have been derived from enstatite, since unaltered nuclei of this mineral are found in it. The vein asbestos ranges from a fibre of microscopic length up to ¾ of an inch as thus far exposed. It is fine and silky and of excellent grade. It would, however, be classed as second grade according to the Canadian practice, which makes a first grade, of fibre above ¾ of an inch (about 2½ inches being the maximum), and a second grade of ⅜ in. to ¾ in. All below this and all fibre not vein fibre goes to the mill and is mechanically separated, as the third grade. In the Vermont localities the slip fibre is exposed on the property of the New England Co., and of its neighbor, the American Co. The vein fibre is limited so far as yet opened up to the property of Mr. M. E. Tucker and associates.

It is difficult with the data in hand, which were gathered under the direction of Dr. C. W. Hayes, of the U. S. Geological Survey, to trace the geological history of the serpentine, but it must have been originally either an igneous pyroxenyte, or a richly magnesian siliceous limestone. There are such slight traces of calcium-bearing minerals however, that the former supposition has the greater weight. The hornblende-schist consists of common green hornblende and of an unusual amount of titanite, there being little else than these two present.

Professor Kemp also gave a paper on the *Physiography of Lake George.* The observations extending over several years have suggested the following conclusions. Lake George occupies a submerged valley very similar to many others in the Adirondacks, which are not submerged. The valley has been largely produced by faulting, and the fault-scarps still remain in precipitous cliffs, whose sharpness has not been much affected by the weathering and erosion. Before the Pleistocene, the valley was probably a low pass with both a north and a south discharge. The portion rich in islands near Pearl point, and the Hundred Island house, was probably the divide, and the islands represent the old hillocks near the top of the divide. At the south the water is backed up by sands and morainal matter in the valleys on each side of French mountain, viz. at the head of Kattskill bay, and at Caldwell. On the north they are held in by Champlain clays and syenitic gneiss at the Ticonderoga outlet, and probably by morainal material at the low pass just south of Rogers rock and leading out to the very depressed Trout brook valley, just west of Rogers rock and Cook mountains. Trout brook is now as much as a hundred feet lower than lake George at points south of the Ticonderoga barrier. The northern barrier is rock because the Ticonderoga river passes through a narrow and shallow channel in the exposed ledges a mile south of its actual first waterfall. There is a broad flat valley buried in clays, however, beneath which an old channel may lie submerged. At the same time, the marked depth of the Trout brook valley to the west makes this the natural outlet and there is reason to believe from the general topography that the discharge passed north into the Champlain valley near the south boundary of Crown Point. It is also not to be overlooked that a valley with much drift leads eastward to lake Champlain, from the head of Mason's bay.

A curious feature that is common to both shores of the lake north of Sabbath Day point (and perhaps also south of it), is the presence of pot holes of great perfection and as high at times as thirty feet above the present level of the lake. These are best developed on Indian Kettles point, about two miles north of Hague. They are doubtless excavated by lateral or subglacial streams when the ice filled the lake valley, because in no other conceivable way could flowing water be forced into such unnatural situations.

There is great need of a good hydrographic survey of the lake, and of detailed pilot charts, with soundings. They would be of great service, not alone to navigators, but to science as well. So far as could be learned from local fishermen, whose deep trolling for lake trout gives them familiarity with the bottom, there appear to be channels whose general trend is parallel with the long dimension ofthe lake, and which have precipitous sides, precisely like the valleys and gulches now visible. The lake is relatively shallow as compared with lake Champlain. In lake George, the greatest depth is believed to be near "Anthony's Nose," and to reach 190 feet. Elsewhere the deep parts are placed at about 100 feet more or less. All this, however, requires confirmation

by soundings; and with regard to the physiography one cannot say to what extent the bottom of the valley has been filled by drift, but the islands to which physiographic importance has been given by the speaker are rock.

RICHARD E. DODGE,
Secretary pro tem.

PERSONAL AND SCIENTIFIC NEWS.

PROF. W. O. CROSBY of the Institute of Technology, Boston, spent the summer in Arizona in the examination of certain mines.

PROFESSOR J. B. HATCHER, in camp near Canyon City, Colorado, has discovered the remains of another fossil animal in the famous bone beds of that section.

PROFESSOR W. B. SCOTT, of Princeton University, is still in South America working on the Patagonian reports. When last heard from he was at Buenos Ayres, examining specimens in the Museum of that place.—*Science.*

GEORGE B. SIMPSON who has been connected with the New York state department of paleontology since 1868 and thousands of whose beautiful drawings of paleozoic fossils have been reproduced in the publications of that department, died Oct. 15, at Albany.

MOVEMENTS IN THE ROCKIES. "The mountains are constantly moving," was the remark of an officer of the Denver & Rio Grande Road recently in speaking of the great landslides in the canyon above Glenwood Springs, Colo. "We find from actual experience in maintaining tunnels, bridges and tracks in the mountains that the mountains are moving. It costs a railway passing through the mountains a great deal of money in the course of ten years to keep the tracks in lime, and maintenance of tunnels is even more expensive. Drive a stake on the side of a mountain, take the location with the greatest care, and return after a few months. The stake is not in the same location. The whole side of the mountain has moved. This experiment has often been tried and in all cases the result proves that the mountains are moving. The mountains are gradually seeking the level of the sea."

While we do not agree with the last assertion that "the mountains are seeking sea level," there appears no question but that local movements are in progress in the Rockies and the observation of the railroad surveyor is confirmed by those experienced in some of the mines. In quite a number of mines located on fissure veins or between highly tilted strata, or in the vicinity of great faults, movements have

been for a long time observed, and sometimes of so pronounced a nature that timbers after a few years are found so out of place as to require a complete new timbering of portions of a mine, and these movements do not seem to be the result as in coal mines of a creeping from excavation of material, but actual slipping or faulting movements of the mountain itself along certain lines, especially old fault planes and veins, the latter generally occupying fissures along fault lines.

A notable instance is in the mines of Smuggler mountain, at Aspen, Colo., where in some of the deep workings, timbers two feet thick and eight to ten feet long placed across the stopes are snapped in two like reeds and their ends broomed up by the overwhelming pressure and slipping movements of the walls. The ore bodies lie between strata almost vertically uptilted against a granite mountain or wall, and abound in faults and slipping planes. These movements are not the result of excavation of the ore, but appear to come from a general movement of the hills slipping or faulting off from the granite wall.—*Mines and Minerals, of Scranton, Pa., for September, 1901.*

FIELD COLUMBIAN MUSEUM SIXTEENTH FREE LECTURE COURSE, Autumn, 1901. A course of nine lectures upon Science and Travel has been arranged by the Museum for Saturday afternoons in October and November at the usual hour, 3 o'clock. All of these lectures will be illustrated by stereopticon views. The lectures are given in the Museum Lecture Hall. Entrance doors will be closed at ten minutes past 3 o'clock. Admission free. Subjects, dates and lectures: Oct. 5, The Megalithic Monuments of Brittany, Dr. George A. Dorsey, Curator, Department of Anthropology, Field Columbian Museum; Oct. 12, Through the Arizona Cañon and Yosemite to the Glaciers of Alaska, Dr. Edward Burton McDowell, Chicago; Oct. 19, The Houses and Family Life of the Natives of Sarawak, Borneo, Dr. Alfred Cort Haddon, F. R. S., F. Z. S., University of Cambridge, England; Oct. 26, The Ceremonial and Secular Dances of the Papuans, Dr. Alfred Cort Haddon, F. R. S., F. Z. S., University of Cambridge, England; Nov. 2, Economic Geology, Particularly of Michigan, in its Relation to the Business World, Prof. Alfred C. Lane, State Geologist, Michigan; Nov. 9, Color in Nature, Prof. William H. Dudley, Platteville, Wisconsin; Nov. 16, Mexico, Dr. S. E. Meek, Assistant Curator, Department of Zoology, Field Columbian Museum; Nov. 23, Recent Dinosaur Discoveries, Mr. Elmer S. Riggs, Assistant Curator of Paleontology, Field Columbian Museum; Nov. 30, Crystals, Prof. O. C. Farrington, Department of Geology, Field Columbian Museum.

ANOTHER KANSAS METEORITE. Still another meteorite has recently been added to the list of finds and falls for which Kansas is becoming celebrated. The last reported find is from Admire, Lyon county; a stony iron of the type referred by Brezina to the Rokicky group. The only other representative of this group yet found in America, is that of Eagle Station, Carroll county, Kentucky.

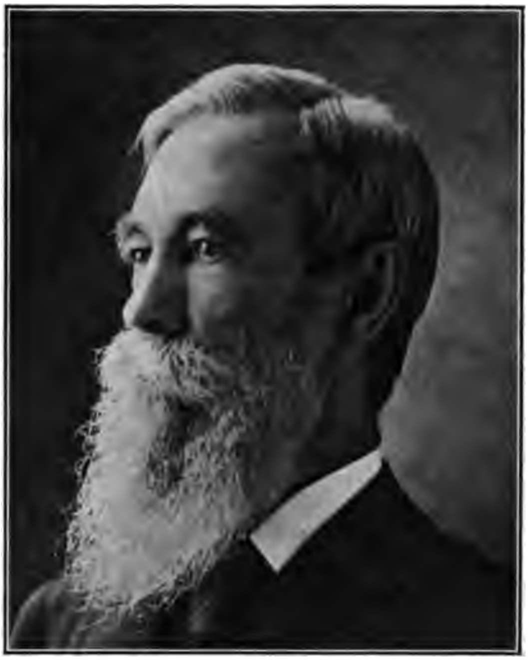
The date of the fall of the Lyon county specimen is unknown, but its badly oxidized condition indicates that it has been lying in the ground for many years.

Some twelve kilograms of the material has thus far come into the possession of the National Museum at Washington, but the entire amount of the fall cannot be accurately ascertained. It will be known as the Admire meteorite.

DIFFICULTIES OF DEEP COAL MINING. In an article recently read before the North Staffordshire Institute of Mining and Mechanical Engineers (England), by Mr. Percy Turner upon the subject of "Coal Mining at Depths Exceeding 3,000 Feet," he discusses the subject under the following heads: 1st, Increase in Temperature; 2d, Increase in Pressure; 3d, Winding Difficulties; 4th, Increased Expenditure. His conclusions are as follows: "The depth, then, to which coal mines may extend depends upon human endurance of high temperatures, upon the possibility of reducing the humidity and temperature of the air, and upon the liability to gob fires. The possible working of very thick seams (from 15 to 30 feet) appears to be less than seams up to seven feet in thickness. Owing to the impracticability of completely packing horizontal thick seams, and the consequent necessity of supporting the roof with timber, and of finally allowing it to break down, instead of settling as it would if the goaf were packed, the effect of pressure becomes a serious matter. Indeed at 2,000 feet the difficulties are considerable, and at a depth of 3,000 feet, they would probably be such as to render packing impracticable.

The possible depth from which coals can be worked does not appear to be limited by any consideration of a mechanical nature. With regard to drainage, it has been proved in most Cornish mines that the volume of water does not increase beyond a certain point, with increased depth. The comparatively shallow depths intercept most of the water, leaving only a fixed quantity to deal with in the sump. In the coal fields, water is rarely if ever, met with at great depths.

The limit of depth taken by Prof. E. Hull, in 1860, and by the Royal Coal Commission, in 1870, was 4,000 feet. Prof. W. Galloway, however, says "it is probable that a depth of at least 8,000 feet will be attained, even in those localities in which the rate of increase is as much as 1 degree Fahr. in 60 feet." —*Mines and Minerals.*



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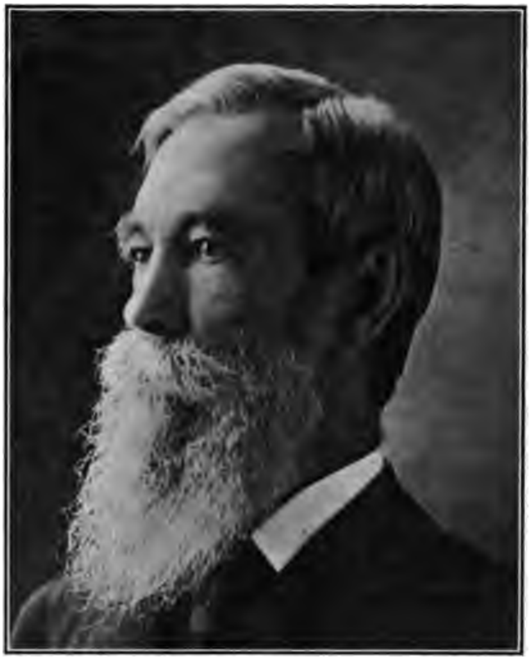

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THE

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RALPH DUPUY LACOE.

By REV. HORACE EDWIN HAYDEN, M. A.,
Corresponding Secretary, Wyoming Hist.-Geol. Society, Wilkesbarre, Pa.

PORTRAIT.

Mr. Ralph Dupuy Lacoe, who died at his residence in Pittston, Penn., February 5th, 1901, was one of the few scientists in America who have attained distinction in his special department of paleontology. Indeed in this line of study the number of persons capable of filling his place immediately is very limited. Mr. Lacoe was born in Luzerne county, Pa., November 14th, 1824. He was the youngest son of Mr. Anthony Desire Lacoe and his wife Emilie Magdalena Dupuy. His father came to Philadelphia in 1792 from his home in Havre, France, under the care of Francis Gurney, the eminent merchant of Philadelphia, remaining with him four years to learn his business. Then preferring a mechanical training he bound himself to learn the business of carpenter and builder. The yellow fever, which in 1798 carried off his master's family, drove Lacoe to the Wyoming valley where he practised his trade with success until his death which occurred at the age of 103 years. The mother of Ralph Dupuy Lacoe was the daughter of an intelligent and well educated Huguenot gentlemen, Jean Francois Dupuy, who left his home in France to live in the island of St. Domingo, and was driven from there by the insurrection of 1791, locating in Wilkes Barre. Mr. Dupuy had been a man of wealth and high standing in his West India home. Charles Miner, the historian, says of him: "Jean Francis Dupuy, a French gentlemen from St. Domingo, exiled from thence by the success of the blacks, a very estimable and intelligent man,

who from having been a wealthy planter, was reduced for a time to rely on personal labour; in the Masonic Lodge he forgot his misfortunes, and there, and nowhere else that I ever saw, assumed the proper station of an intelligent French gentleman, instructing and entertaining us by his philosophical views, occasionally peculiar, as well as by the numerous facts the state of the country he had lived in enabled him to give."

Mr. Ralph D. Lacoe had few advantages of education in his early youth, his mother supplying that which the country schools did not give, and with such success that before he was of age he taught school for a term or more in his neighborhood, having among his pupils the young girl who subsequently became his wife. About 1850 he and his brothers went to Nicholson, Luzerne Co., where his grandfather, Jean Dupuy's land was located; he invested in coal lands near Pittston, and when coal enterprises began to develop he engaged in the real estate business near Pittston, laying the foundation for his wealth of land and other property. In 1850, when the Pittston bank was established, he became cashier, and in 1865, when the bank was made a National Bank, he was elected vice-president. He was also president of the Wyoming Valley Knitting company in 1874, president of the Water Street Bridge company, trustee of the Miners' Savings bank of Pittston, &c., &c.

When about 1865 his health became somewhat impaired Mr. Lacoe retired from the activities of business and turned his attention to the study of geology, especially in connection with coal mining, and began to accumulate what became one of the largest collections of the fossil plants ever known. This collection was naturally divided into three departments—the Coal Flora, Fossil Insects of the carboniferous beds, and Fossils of the Paleozoic limestone beds.

This special study brought him reputation that has placed his name in the Valhalla of science with that of Lesquereux, Dawson and Cope. As his collections grew in magnitude and value the question naturally forced itself upon him as to their ultimate disposition. The pecuniary value of his work doubtless never entered his mind. He visited many public museums and institutions where such collections were preserved, but was pained with the want of attention and care given to them and hesitated to place the results of his research, and his outlay of

money and study where they might some day be relegated to the shades and be forgotten.

Wisely, he determined to give his immense collection to the United States National Museum at Washington where it would do the greatest good to the greatest number. Permit me to quote the account of this unsurpassed collection published in the annual report of the National Museum: In the report of 1892. Mr. Lester F. Ward, honorary curator of this department, speaks thus:

"No gift of greater importance to the department of fossil plants has ever been made than that by Mr. R. D. Lacoe, of Pittston, Pa., under the terms of which this great collection of fossil plants is to be permanently deposited in the National Museum. The value of this collection, one of world-wide reputation, is far greater than that of the entire amount of the collections in the department prior to the date of its gift. The task of procuring fossil plants from the older formations for use in paleontological and biological research has been prosecuted for nearly twenty years by its donor whose liberal means and scientific and practical mining knowledge, as well as his favorable location in the heart of the northern arthracite coal field have enabled him to bring together an invaluable body of material, of which professor Lesquereux remarked in one of his last publications, 1886:"

"'Mr. R. D. Lacoe, of Pittston, has procured, from almost all the localities where coal is worked in the United States, an immense amount of specimens far beyond any seen even in the largest museums of Europe.'"

"Since the above quotation was written Mr. Lacoe has continued his work, having several collectors in his employ in the various states and the Acadia provinces, a portion of the material collected having been examined by professor Lesquereux. Besides gathering this material in the field he has also purchased a number of private collections, containing may type specimens, so that it is perhaps safe to say that nearly one-half of the types of the American Carboniferous flora now lie within the Lacoe collection. In fact, there are few outstanding American types except those resting in several state geological museums.

"But even the deficiency in the balance of originals has largely been compensated for by the collection of duplicates from the type localities, and these, like all other collections made prior to 1889, were examined and labelled by the original author of nine-tenths of the Paleozoic species described from the United States, Leo Lesquereux.

"How prominent a part this material has taken in both the biological and economic applications may be recognized at a glance in the three volumes of the 'Coal Flora,' report P, Pennsylvania Geological Survey, 1878-1884.

"It will at once be seen that the occasion of this invaluable wealth of material will necessarily make this institution, as a repository of the

types of authentic species of nearly all the American Paleozoic species, the reference centre for all the extensive work on the Paleozoic flora in this country in future, as well as the custodian of valuable geological correlation data. But the proper installation in this museum of so great a collection, numbering about 100,000 specimens, is a matter involving much embarrassment in the way of space and study facilities, it being agreed in the terms of the gift that this collection, to be kept entire and known as the 'Lacoe Collection,' shall, together with all the future additions, either by exchange or gift of the donor, be kept in order and made accessible to scientists and students, without distinction, under such proper rules and restrictions as may be necessary for the preservation from loss or injury of the specimens.

"The area required for the type specimens, making no allowance for increase, amounts to over 1,000 drawers the size in ordinary use in the museum. The exhibition material will occupy about 2,100 square feet. * * * * This rich possession affords just ground for national scientific pride, while the liberal public spirit with which it was given is worthy of imitation by all patrons of science." (Report of 1892, 186.)

In 1896 professor G. Browne Goode, assistant secretary of the Smithsonian Institution, said of Mr. Lacoe's gift:

"The transfer of the magnificent Lacoe collection from Pittston, Pa., the residence of the donor, to Washington was completed during the present year. It was included in 315 boxes. * * * It is not too much to say that the National Museum has never received a gift of greater scientific value or importance than that acquired through the generosity of Mr. Lacoe." (p. 73.)

The number of original Paleozoic plant types in the museum prior to the reception of this gift was 102, the number in Mr. Lacoe's collection 575, the number of specimens 100,000. Mr. Lacoe continued until his death to enrich this spelndid collection. In 1898 he presented to the National Museum an extensive collection of fossil insects, of more than 200 types and nearly 5000 specimens. He also added over 100 invertebrate fossils, over 400 vertebrate fossils, and 132 fossil plants. Of the main collection, 804 fossil plants from the Dakota group were described with plates by Prof. Lesquereux in Monograph XVII of the U. S. Geological Survey. Among the fossil plants, Lesquereux named in honor of Mr. Lacoe eight types, *i. e.*, *Phyllites lacoei*, *Magnolia lacoeeana*, *Crataegus lacoei*, *Jnglandites lacoei*, *Caulopteris lacoei*, *Cordaites lacoei*, *Lepidostrobus lacoei*, and *Stemmatopteris lacoei*. Mr. David White has also named two types after Mr. Lacoe, *Sphenopteris lacoei*, and *Alaethopteris lacoei*. In his latest *MSS.*, yet unpublished, Mr. White names a new genus, *Lacoea*.

Mr. Lacoe preferred to be student rather than a writer, but he has left the seal of his authority as an expert in his special department. Prof. J. P. Lesley, state geologist of Pennsylvania, in his geological report of Wyoming, Lackawanna and Luzerne counties, Vol. G7, Pennsylvania Survey, gives him full credit and the highest praise for his assisstance to the survey. In referring to the "Buried Valley of Wyoming" he says: "I am indebted for most of the records of drilling by the various mining companies to Mr. R. D. Lacoe of Pittston, who has done so much through his magnificent collections to advance our knowledge of the coal flora of Pennsylvania and other states."

Prof. Scudder, in his valuable work on American Fossil Cockroaches, 1895, says: "When in 1879 I published my Paleozoic Cockroaches, in which a revision of the species of the whole world was attempted, I had seen but nineteen specimens from North America belonging to seventeen species and seven genera. To-day more than three hundred American specimens have passed under my eye, besides fifty from the Triassic rocks and a very few from the Tertiary series, and from the Paleozoic series alone there are here recognized one hundred and thirty-two species belonging to fourteen genera. This recent extension of our knowledge of our Paleozoic cockroaches is very largely due to the exploitations of two localities—one in West Virginia, through the instrumentality of Mr. R. D. Lacoe of Pittston, Pa., the other in Ohio, through the labours of Mr. Samuel Huston of Steubenville, the West Virginia collection numbering 56 species and 5 genera." Prof. Scudder also describes 18 specimens of as many species in Mr. Lacoe's collection found by him in the Boston mine near Pittston. One of these was named in honor of Mr. Lacoe, "*Neymylacris lacoeana.*"

Mr. Lacoe was a Fellow of the American Association for the Advancement of Science, elected to membership August, 1882, and made a Fellow of the American Geological Society December, 1889. It was thought that he was also a member of the Geological Society of London.

In 1882 Mr. Lacoe became a member of the Wyoming Historical and Geological Society located at Wilkes Barre within ten miles of his home. His interest immediately manifested itself in a practical way by adding to its geological collections.

He became a trustee of the society in 1882 and continued one until 1889. He was also curator of paleontology in the society from 1884 to 1899, for fifteen years, when he was succeeded, at his own request, by Prof. Joshua L. Welter, the present curator. He became a life member February 8th, 1889. In 1898 he presented the society the three large cases of drawers of one hundred each which now contain the coal flora of the society, had them moved and placed in position, added largely to the specimens now forming the collection, and personally arranged them in the drawers. Of these specimens many have been identified by Prof. Lesquereux, whom Mr. Lacoe brought to the rooms for the purpose when he was visiting him in Pittston.

Of this collection Mr. Lacoe stated in his report as curator in 1886: "Many of the genera are well represented in typical series, some of which are very fully illustrated by large and fine specimens. A moderate outlay of money and well directed efforts on the part of members and friends of the society would in a short time add greatly to the value and usefulness of your collection, which already compares favorably with the best in in the country." (Proceedings, Vol. II, 160.)

Mr. Lacoe also largely aided in forming a model case in the geological room of the society, illustrating the "crust of the earth," showing its geological strata from the Archean to the Cenozoic age, a practical exemplification of the geological epochs for the use of the public schools of his section. He did not spare his own collection of fossils to enrich this model. In 1899 he presented this society with a fine collection of Paleozoic invertebrates numbering over 1,200 species and 4,500 specimens. This collection I had the great pleasure of packing, removing, and arranging, with the curator of paleontology, in the cabinet made for it, and marked, "Lacoe Collection of Fossils." A catalogue of these Fossils was published in the "Proceedings and Collections &c." of the society, 1900, Vol. V, pp. 177-204. It was also printed in a separate pamphlet entitled, "Report of the Curator of Paleontology on the Lacoe Collection of Fossils, 8vo., pp. 28, 1900."

Mr. Lacoe was married in Pittston by the Rev. N. G. Parke, D. D., April 26, 1860, to Miss Bridget Clary, who died October 31, 1872. He had four children—Josephine, who died

early; Margaret Clary, now Mrs. I. S. White, of Rock Island, Illinois; Ralph Dugué, of West Pittston, and William Clary, who died young.

Mr. Lacoe was a devout Christian, baptized by Rt. Rev. Wm. B. Stevens, LL. D., 1866, confirmed by him in St. James' church, Pittston, and for many years a member of the vestry. He was also, in 1883, one of the organizers, and for years junior warden and treasurer of Trinity church, West Pittston. He was a loyal and generous churchman, liberal in his gifts, and faithful to the dear mother by whose beautiful ritual he was laid to rest. Mr. Lacoe was also a generous promoter of the Pittston Library, and in many ways, known only to the few, he delighted to aid and assist worthy objects in his town, and worthy young men to better things and nobler lives.

Mr. David White, honorary curator of Paleozoic plants (Lacoe Collection), U. S. National Museum, and an intimate personal friend of Mr. Lacoe, writes thus enthusiastically of Mr. Lacoe's relations to science.

"By the death of Mr. Lacoe science and scientists have lost a worthy and devoted friend of rare quality and strength of character. Mr. Lacoe's position in the scientific world was somewhat unusual. He was an authority on the geology of the northern anthracite coal field; his extensive knowledge in the domains of fossil plants and fossil insects was recognized on both sides of the Atlantic; his experience and observations were well supplemented by reading, and his opinions, whether concerning the structure and correlation of the Wyoming Valley coals or touching the problems of systematic paleontology, were often sought and always highly valued by specialists in paleozoölogy and paleobotany. Yet he never published more than one short article; he never described a single genus or species. So modest and unassuming was he, so small an estimate had he of his own ability and attainments, and so wholly wanting was he in the love of the notoriety of authorship, that he transferred to others for description and publication the new genera and species which he, while posing as a layman, was an expert in detecting. Always desiring that the fossils in his collection should be systematically labelled at the hands of the highest American authorities on the subject, he was accustomed, even to the last, to submit his specimens to others for study and determination. Even among the numerous representatives of the commonest and most easily recognized species, there are in his great collection comparatively few specimens whose labels show himself to have been the authority for their determination, although in the latest years of his studies of fossil plants he was himself fully competent, as far as knowledge and experience are concerned, to have determined, described and published the greater part of his paleobotanical material.

To the scientific world in general, beyond the circle of his personal friends and acquaintances, Lacoe was widely known as a promoter or patron of science; and it was in this capacity that he did his greatest and best work. The occasional collecting of fossils, begun as an out-of-door recreation beneficial to his failing health, quickly developed a profound and enthusiastic interest in th plant-life of earlier geological time and the remarkable discoveries resulting from paleontological research. At first he made extensive collections of coal plants from the Wyoming Valley coal field. Realizing at an early date the very great handicap to the progress of paleontology resulting from the enormous labor and expense of exhuming, intelligently collecting and bringing the raw fossil material to the hand of the paleontologist, he chose, for his part and service, to promote the advancement of science by gathering the materials for and facilitating the work of the paleontologist. Accordingly, he began systematically to procure, through the aid of collectors, by purchase, exchange, or with his own hands, collections to show the plant life in various geological epochs, but chiefly Paleozoic, in different countries and continents, as well as from the coal fields of this country. Becoming interested in the occasional remains of insects, which, very rare at best, are seldom discovered except in their natural association with fossil plants, Lacoe also entered upon the systematic collection of fossil insects and crustacea as well."

"Lacoe's aid to science did not end with collecting the fossils and placing them in the hands of the appropriate specialists. Whenever a paleontologist was so situated as to be dependent on his daily labor for his livelihood, Lacoe made it possible for him to carry on his researches in the material placed in his hands. In many additional cases the expense of preparing suitable drawings, so essential in paleontological publications, was also borne by him. It deserves to be added, to the disgrace of a State great in many respects, that in order that the invaluable data of the Lacoe collections relating to the geographical and stratigraphical distribution of the species might be included and made available in the Pennsylvania state geological report on the Coal Flora; that the stratigraphic and correlative values of the species might be ascertained and the described species made satisfactorily recognizable by means of adequate illustration, Lacoe largely bore the expenses of the paleontological study of the collections and guaranteed the compensation for a part of the illustrations. He was further the benefactor of the State through the presentation of extensive series of specimens to its geological museum. He was also bearing the expense of the paleontological study and of the preparation of manuscript and illustrations of the materials to form a supplementary volume of the Coal Flora to be published by the State, when the failing health and death of Prof. Lesquereux left the work incomplete. Before the resumption and completion of the work the state survey was abolished."

Single handed and with but slight aid among his friends, Lacoe quietly did for science a work of a kind that is rarely prosecuted except by the wealthier universities, endowed scientific societies, or special

scientific institutions. His extreme modesty regarding the importance and value of his collections, and the patriotism shown in the disposition of the results of so great personal labor and care, are a moral object lesson to wealthy patrons of science.

"The greatest and most enduring monument to Lacoe's devotion to and work for science is the Lacoe collection. Carefully guarded against danger or deterioration, it will be increased in numbers from time to time by exchanges or additional gifts. Visitors to the paleontological halls of the Nation's Museum may see an exhibit comprising a small portion of the more imperishable and attractive specimens of 'The Lacoe Collections,' the greater number studied and identified by the foremost paleontologists of the time. Its types, from the hands of Lesquereux, Dawson, Scudder and Cope, will be consulted and re-examined by the savants of paleontology for centuries to come. Students of life distribution, climate and of evolution will review its suites of specimens, and their records will supplement the records of the great paleontologists of the past who have participated in its original elaboration. These records are in the paleontological literature of every land; and while there shall remain a literature or a human interest in paleontology, the name and scientific service of R. D. Lacoe will be perpetuated. The collection tells its own history; it tells of its author's intense interest and devotion, and of his great personal labors and aid in behalf of palæontology and geology; by the notes and inscriptions, the patient and loving care in registration, the comments and remarks it tells of its relations to the students, of congenial scientific discussions, and of warm and lasting friendships between paleontologist and patron, welded on the fossil anvil. The best, the most lasting scientific memorial of our friend and fellow is the great Lacoe collection."

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THE LOESS OF IOWA CITY AND VICINITY.*

By B. Shimek, Iowa City, Iowa.

The loess of Iowa City presents no unique features. It is of the type which prevails in the eastern part of the state, being fine and homogeneous; found chiefly on highlands, especially in its undisturbed condition, and following their vertical contours, thus varying but little in thickness which seldom exceeds twelve or fifteen feet; containing both tubules and loess-kindchen in the usual varying proportions; and more or less fossiliferous. It has been quite fully discussed by McGee†. Lists of the fossils which are found about Iowa City have already been published,‡ and it is not the purpose of this paper to offer much that is new in this direction, but rather to present a detailed account of the habits of the local modern molluscs, and their bearing on the loess.

In probably no other locality in the country have these modern and loess faunas been studied side by side more fully than at Iowa City. Besides the early work of Witter, and that of Keyes (chiefly upon State University Museum specimens collected and identified by the writer), the efforts of Pilsbry and Bayard Elliott were especially noteworthy, though the former published but little, while the latter made no permanent record of his observations, but submitted a part of his collection to the present author, who has been engaged in loess and mollusc studies with more or less interruption for many years, and has gathered together great numbers of both fossil and modern forms which bear on this question.

The lists representing these faunas are therefore more complete than is possible where resident observers are not engaged in the investigation of both branches of the subject, and this

*Excerpt from the *Bulletin* of the Laboratories of Natural History, State University of Iowa, vol. v; No. 2, pp. 195-216.

†*U. S. Geol. Sur.*, vol. xi, pt. i, 1891.

‡W. J. McGee, *l. c.*; C. L. Webster, *Am. Nat*, May; 1887, p. 419; B. Shimek, *Am. Geol.*, vol. i, pp. 149-152, 1888; *Bull. Lab. Nat. Hist.*, State Univ. Ia., vol. i, pp. 200-209, 1890; etc.

fact, coupled with the comparative richness of both faunas, makes a comparison of them especially interesting and suggestive. Since all of the fossils which have been found at Iowa City are molluscs, and belong with few exceptions to the local modern molluscan fauna, a study of the habits of the living species is of the highest importance because of the light which is thus thrown upon the conditions which existed during the deposition of the loess. The species included in this list are therefore grouped according to habit in order that comparisons and conclusions may be facilitated. All notes on distribution, etc. of both modern and fossil shells in the following list have reference to the vicinity of Iowa City only, unless otherwise specifically stated. "Western loess" means that of western Iowa and eastern Nebraska. The material was abundantly collected and studied in the field by the author, and is now in his private collection.

The names of the local fossil (loess) species are preceded by two asterisks. Those which have been found fossil in the loess in other localities, but not at Iowa City though now found living here, are marked by one asterisk. The latter series does not however include all the species of the modern fauna of Iowa City which were reported in the earlier Missouri and Nebraska lists of loess fossils, as no specimens are extant and the species are not now known to occur in undoubted loess. The species living near Iowa City but not represented in the loess are unmarked. The territory covered by this report is included within a radius of six miles from Iowa City.

RECENT AND FOSSIL MOLLUSCS AT IOWA CITY.

I. Species here found only as fossils.

**Pyramidula shimekii *(Pils.) Shim.*

Quite common in the loess of Iowa City, which furnished the type specimens. A more complete discussion of this species is given on pp. 139-145 of this Bulletin.

**Pyramidula strigosa iowensis *Pils.*

This variety is now extinct. All other forms of this extremely variable species however belong to the dry western plateaus and mountains. It is locally quite common in the loess, and the type specimens were from this locality.

**Pupa muscorum *(L.)*.

Now living in the U. S. from Maine to Montana, thence to Nevada. Also in Europe. Not rare in the loess.

**Pupa blandi (*Morse*) *Binn.*

Two specimens were recently found in the loess near Iowa City. It is not rare in the western loess, and is found living from New Mexico to Montana. The shells usually formerly reported under this name are *Bifidaria pentodon*(?). The easternmost localities from which fossils have been received are Muscatine and Stockton in Muscatine county, Iowa. They were erroneously reported as *P. muscorum*.*

**Vallonia gracilicosta *Reinh.*

Quite common in the loess. It is common in western and northwestern Iowa, and thence westward, where it lives in high, dry situations. Its easternmost known station in Iowa is in Winnebago county.

**Succinea grosvenorii *Lea.* (?)

A form referable to this species is quite common in the local loess. The species now lives abundantly in the South, and in Nebraska and western Iowa, and is uniformly found (so far as the writer's experience shows) in situations which are exposed to severe drouth during at least a portion of each year.

The Succineas of this group, both recent and fossil, require further elaboration.

It is interesting to note that the foregoing species, now extinct at Iowa City, all belong to the modern terrestrial fauna of the dry west, from Montana to New Mexico, and that only two species extend eastward as far as Iowa.

2. Terrestrial species, now living at Iowa City.

a. Species of higher, more or less exposed, and often rocky slopes.

*Vallonia parvula *Sterki.*

Common on exposed rocky slopes, hence occurring in scattered colonies. Rare in the loess of western Iowa.

*Leucocheila fallax (*Say*) *Try.*

*Through the writer's error they were reported in Prof. Udden's, note on Hershey Ave. fossils in Leverett's Report in *U. S. Geol. Sur.*, vol. xxxviii, p. 174, 1899. In that list *P. blandi* should be substituted for *P. muscorum* Also in Udden's Report, *Ia. Geol. Sur.*, vol. ix, p. 359, 1899, where the same substitution should be made in the Fulton township (Stockton) list. *P. muscorum* does however occur at Muscatine.

Locally common on higher exposed slopes, chiefly under fragments of limestone. Rare in the loess of western Iowa and eastern Nebraska.

**Bifidaria armifera (*Say*) *Sterki*.

Very common. Most frequent on more or less exposed slopes under limestone, among roots of grasses, etc. Sometimes also in deeper shade, and occasionally on lower grounds, under logs, etc. Rare in the loess at Iowa City, but very common in the western loess at Council Bluffs, Iowa.

*Bifidaria holzingeri (*Sterki*).

Quite common under stones, etc. on exposed hillsides. Rather rare in western loess.

**Bifidaria pentodon (*Say*) *Sterki*.

Quite common on rather open rocky slopes, sometimes on lower grounds, under stones, etc. As a fossil this species is widely distributed, and in this locality is very common.

*Bifidaria curvidens (*Gld.*) *Sterki*.

Not uncommon. It is rare in the loess of the west and south, but has not been found fossil at Iowa City.

*Bifidaria corticaria (*Say*) *Sterki*.

Common in a few restricted localities among the roots of tufted grasses, etc. growing on exposed rocky slopes. Not found in the local loess, but reported from Des Moines by Keyes, from Muscatine by Witter and from Illinois by Leverett. It is not rare in the loess of Natchez, Miss.

*Polygyra leai (*Ward*) *Pils*.

Found here under sticks, etc. on slopes near a prairie swamp. Also more rarely on scantily wooded slopes. Rare in the loess of the west, etc.

*Succinea avara *Say*.

Not rare on more or less exposed rocky slopes. This is the small, typical form which is now found on low grounds. The same form occurs abundantly as a fossil, being one of the most characteristic species of the loess. It occurs in all the fossiliferous exposures near Iowa City, being the only fossil found in some of them.

**Vitrea indentata (*Say*) *Pils*.

Not rare on rocky slopes. This, and the following species, also occur on lower grounds, but both are more common on drier slopes. Rare in the loess.

**ZONITOIDES MINUSCULUS (*Binn.*) *Pils.*

Common under stones, etc. on higher slopes, and under sticks, leaves, etc. on lower grounds. Rare in the loess.

b. Species of higher, more deeply shaded (often mossy and rocky) banks and slopes, sometimes in deep woods.

**HELICINA OCCULTA *Say.*

This species, though a prosobranch, is strictly terrestrial in its habits. It is found living in but one locality, a steep, rocky northern slope near Turkey creek, six miles north of Iowa City, the locality in which it was first discovered by the writer about twenty-two years ago. It is quite abundant in this very restricted locality, being found under stones and fallen leaves. It is very common in the loess, and is found in nearly all the exposures. The body-whorl of the fossil shell sometimes still contains the operculum.

The writer recently found this species (living) common on the rocky slopes along Pine Hollow creek in Dubuque county, and Little Turkey river and its small tributaries in Clayton county, Iowa localities not hitherto reported.

**POLYGYRA PROFUNDA (*Say*) *Pils.*

Common under sticks, stones, leaves, etc. on higher shaded slopes. It is found in but one loess-exposure in this vicinity, but is very common in the loess of Natchez, Miss.

*POLYGYRA CLAUSA (*Say*) *Pils.*

Widely distributed in deeper woods near Iowa City, but nowhere common. As a fossil it is rare, occurring occasionally in more southerly loess. None have been found at Iowa City.

*POLYGYRA HIRSUTA (*Say*) *Pils.*

Locally quite widely distributed in deeper woods, though never gregarious. Fossil shells are found sparingly in the western loess at Council Bluffs, Iowa.

*POLYGYRA MONODON (*Rack.*) *Pils.*

This species is very similar to the preceding in its habits, and in the distribution of both the recent and fossil forms, both, however, being rather more abundant. Neither has been found fossil at Iowa City, though their discovery would not be surprising. Common in the loess at Natchez, Miss., and also fossil in Indiana.

*STROBILOPS VIRGO (*Pils.*).

Locally common on rocky, shaded slopes. It is occasionally found fossil in the western loess. This has ordinarily been reported as *Strobila labyrinthica* Say.

VERTIGO MILIUM (*Gld.*) *Binn.*

Not common, on mossy banks and slopes. Not found fossil. Its minute size might easily cause it to be overlooked.

**VERTIGO OVATA *Say.*

Rare, on mossy, shaded banks, sometimes on lower grounds. Somewhat more common as a fossil, occurring sparingly in several of the exposures.

*VERTIGO BOLLESIANA (*Morse.*)

Rare, on mossy banks, usually in shady places. It is rare in the western loess.

*VERTIGO TRIDENTATA *Wolf.*

Locally common, usually on rather exposed rocky, moss-covered banks. Found sparingly in the western loess.

**COCHLICOPA LUBRICA (*Müll.*).

Rare on rather open slopes, etc. It is more common as a fossil, but is one of the rarer species of the local loess.

*CIRCINARIA CONCAVA (*Say*) *Pils.*

Widely distributed on shaded, especially rocky, slopes, but not gregarious. It is not found in the local loess, but is quite common southward. It is one of the common fossils at Natchez, Miss.

**CONULUS FULVUS (*Drap.*) *Müll.*

Not uncommon on shaded slopes in moss, and under sticks, leaves, etc. Fossil shells are not rare, and as a rule are better developed than the modern specimens.

*ZONITOIDES ARBOREUS (*Say*) *Sterki.*

Very common, usually under logs in high or low places, and not uncommonly in comparatively open woods. It can not yet be reported from the local loess, but has been found by Prof. Savage in the loess of Henry county, Iowa, and it is not rare in the western loess.

**PYRAMIDULA ALTERNATA (*Say*) *Pils.*

Locally common, usually on higher, deeply-shaded slopes under logs, stones, leaves, etc. Not common in the loess at Iowa City.

**PYRAMIDULA PERSPECTIVA (*Say*) *Pils.*

Common on shaded banks, etc. under decaying logs. This species is not generally distributed in the loess, though it is very common at Natchez, Miss. At Iowa City it occurs rather abundantly in but one exposure.

**HELICODISCUS LINEATUS (*Say*) *Morse.*

Scattered specimens are not infrequent. They are usually found in deeper shade under sticks and logs. Fossil shells are quite rare.

*PUNCTUM PYGMAEUM (*Drap.*) *Binn.*

This minute shell is easily overlooked, but is quite common under sticks and fallen bark on northerly shaded slopes, and among clumps of hazel, etc. on lower grounds. The author collected fossil shells in the loess of Natchez, Miss., but none have yet been found in the northern loess.

**SPHYRADIUM EDENTULUM ALTICOLA (*Inger.*) *Pils.*

While this form scarcely deserves rank as a variety, the name is here retained to designate the common loess fossil which is identical with recent shells (commonly known under the varietal name) which are now found in Wyoming, Colorado, etc. This form is much elevated, and has a distorted body-whorl, which destroys the symmetry of the otherwise almost perfectly cylindrical shell. Typical *edentulum* is exactly like the upper part of the shell of the variety and is a less fully developed form. An occasional shell of the varietal form is found eastward with the type. Speaking of the recent shells Dr. Sterki says:* "There are, among the common form, high specimens with narrower penultimate and wider last whorl, found everywhere occasionally in this country as well as in Europe; and thus *P. alticola* Inger.† is not even a true var. here."

However in the Rocky Mountain region the variety is the common form, and it is likewise generally distributed through the northern loess, belonging to the category of the most common and most characteristic loess fossils.

Only two recent specimens have thus far been taken at Iowa City. As both are rather young shells it is impossible to determine whether they are the type or the variety. As the

*Nautilus, vol. vi, pp. 6 and 7, May, 1882.

†First described as *Pupilla alticola* Ingersoll, in *Bull. U. S. Geol. Sur. of the Ter.*, 2, p. 128, 1875.

distinction between them, however, is not worthy of maintenance, they are here grouped together.

c. Terrestrial species of lower, shaded, alluvial grounds, under sticks, leaves, etc.

**POLYGYRA MULTILNEATA (*Say*) *Pils.* (Large form).

Two forms of this species occur here. The larger, the more common form, lives on wooded alluvial bottom-lands which are not too dry, and may be found abundantly creeping or hiding among the smaller plants, under fallen leaves, etc. Four fossil specimens only were found in one of the exposures at Iowa City, and it is rare in the loess of the Missouri river in eastern Nebraska. The smaller form, discussed under (*d*), is much more common in the loess.

*BIFIDARIA CONTRACTA (*Say*) *Sterki.*

Very common on rather low grounds, under logs, etc., sometimes ascending to higher slopes. Absent from the local loess and rare westward. It is more common in the southern loess.

BIFIDARIA PROCERA (*Gld.*) *Sterki.*

Only one local specimen was collected on rather low ground. Westward this species is quite common in drier situations, under sticks and leaves in clumps of bushes, etc. None have yet been found in the loess.

**VITREA HAMMONIS (*Strom.*) *Pils.*

This name is used for the species commonly known as *Zonites viridulus* Mke. on the authority of Pilsbry. Binney refers *Helix hammonis* Ström. to *Zonites fabricii* Beck,—a species from Greenland.* Our species is quite common under logs, etc. on rather low, more or less wooded, grounds. Rather rare in the local loess, but more common westward.

**PYRAMIDULA STRIATELLA (*Anth.*) *Pils.*

Quite common on scantily timbered alluvial bottom-lands, under logs, fallen leaves, etc. Also on higher slopes. As a fossil it is very common, and is widely distributed; appearing almost universally in our northern loess deposits. Fossil eggs, agreeing exactly with recent eggs of this species, are also frequently found.

**SUCCINEA OBLIQUA *Say.*

Very common under leaves, etc. on timbered alluvial bot-

*W. G. BINNEY, *Terr. Air-Breath. Moll. U. S.*, vol. v, p. 127, 1878.

tom-lands. Westward the species frequently appears on higher grounds. Quite common as a fossil.

*CARYCHIUM EXIGUUM (*Say*) *Gld.*

This species is common in damp places on rather low grounds, under logs, etc. No local fossil specimens have been found, but the species is rare in the western loess.

*POMATIOPSIS LAPIDARIA (*Say*) *Try.*

Locally common with *Pyramidula striatella.* This species, like *Helicina occulta* is a gill-bearing mollusc, yet it is strictly terrestrial in its habits. The author has collected living specimens in widely separated sections of the State, and found the habitat uniformly the same. Not found in the local loess, but reported from Memphis, Tenn.,* from Missouri† and from Arkansas.‡

While the species of this group are more common on lower grounds, most of them occasionally appear on higher slopes. Thus *Polygyra multilineata* (medium sized), *Bifidaria contracta, Vitrea hammonis, Pyramidula striatella* and *Succinea obliqua* are very common on a rather scantily wooded, rocky, steep slope in Iowa City at an altitude of from twenty-five to seventy-five feet above the Iowa river. Most of these species also occur sparingly at higher altitudes in the western part of the State. *Bifidaria contracta* is so common in such situations in all parts of the State, that it might well be classed in group (*b*).

d. Species of mud-flats, edges of swamps, etc.

ZONITOIDES NITIDUS (*Müll.*) *St.*

This species is locally not uncommon under sticks and leaves in low, wet places. It has not been found in the loess.

**POLYGYRA MULTILINEATA (*Say*) *Pils.*

The smaller form, already mentioned, is not uncommon along the edges of a prairie swamp near Iowa City. It is almost exactly like the locally more common fossil form of this species. This small form is also common in other portions of the State,—especially westward.

*SUCCINEA RETUSA *Lea.*

This species is now common on mud, etc. among plants in swampy places. The large variety *magister* Pils. is the com-

*JAMES M. SAFFORD: *Geol. Tenn.*, p. 434, 1869. Reported as *Amnicola.*
†G. C. SWALLOW: *Geol. Sur. of Mo.*, vols. i and ii, p. 215. Also reported as *Amnicola.*
‡R. E. CALL: *Rep. Ark. Geol. Sur.*, vol. ii, pp. 166, 167 and 179.

mon form. A few fagmentary specimens of young shells from the loess of Nebraska are in the writer's possession. They are probably young shells of the variety. None have been found at Iowa City.

**SUCCINEA ———*sp.* (?).

A rather large *Succinea,* which has not yet been satisfactorily placed, is quite common on bare mud-flats along streams, and also occurs in the local loess. In some respects it is intermediate between *S. avara* and *S. obliqua,* sometimes approaching the smaller, more slender forms of the latter species quite closely.

The foregoing species are wholly terrestrial in habit, and moreover, with few exceptions flourish in comparatively dry situations. While all require a certain amount of moisture when active, the lower surface of a fallen leaf, a stick, or a stone, even in a comparatively exposed place, furnishes all that is necessary.

The following summary of the preceding notes is of interest:

Species found at Iowa City only as fossils	6
Species found here both living and fossil	19
Species now found living here, but occurring as fossils in the loess of other localities	19
Species living here, but not yet reported from the loess	3
Total	47

These shells represent more than 90% of the fossils in the loess, and, the fossil fauna so far as it occurs, is very similar to the living surface fauna. The latter is richer in species, but this difference may be only apparent. A close study of the local living fauna shows that species frequently occur in very restricted areas. Different parts of the same slope, often but a few feet apart, not infrequently show much variation in the distribution of species. When we take this peculiarity of distribution of land-shells into account with the comparatively very small total area of all the loess exposures of this vicinity, we can readily see that the opportunities for finding the recent shells are much better.

While, as stated, the great majority of the local loess fossils belong to the preceding list of terrestrial forms, a few additional species of aquatic habit are also sparingly found. In

no case, however, are they generally distributed in the loess, and with the possible exception of *Limnaea caperata* and *L. humilis*, very few individuals are found. In order that the comparative scantiness of the fossil aquatic molluscan fauna may be more fully appreciated a list of the local aquatic species is here given. Those which also occur in the local loess are marked by two asterisks, and those which are positively known as fossils only from other localities are marked by one asterisk.

2. AQUATIC SPECIES NOW LIVING AT IOWA CITY.

a. Species of smaller ponds, etc., which often become dry in summer.

*LIMNAEA REFLEXA *Say.*

Common some years in shallow ponds. Not found in the loess of Iowa and Nebraska, but reported from Missouri by Hambach.*

**LIMNAEA CAPERATA *Say.*

Locally very common. As a fossil it occurs in but few exposures, and in these is usually restricted to narrow bands or pockets, in which it is quite abundant.

**LIMNAEA HUMILIS *Say.*

Very common in shallow ponds, or on mud-flats. As a fossil it occurs with the preceding species, and is even more common.

**LIMNAEA DESIDIOSA *Say* (?).

Some of the smaller fossil shells of *Limnaea* may belong to this species. It is probably found in the loess westward, though in some cases at least the fossils reported under this name undoubtedly belong to the preceding species. Common in shallow ponds.

**PHYSA GYRINA *Say.*

Very common in shallow ponds. Two very small specimens, probably this species, were found in the loess at Iowa City.

PHYSA [illegible]

Very common in ponds, etc. Hitherto reported as *P. heterostropha* Say. In a very large series of shells from Iowa and Nebraska not one specimen of the latter species was found.

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*Trans. Acad. Sci. St. Louis, [illegible] April, [illegible]

PHYSA SAYI *Tap.*

Quite common locally. None fossil.

PLANORBIS CAMPANULATUS *Say.*

Rare locally in ponds. None fossil.

*PLANORBIS TRIVOLVIS *Say.*

Very common in shallow ponds. Reported from Missouri, but, if occurring at all, certainly not common.

*PLANORBIS BICARINATUS *Say.*

Common in shallow ponds. One fossil specimen was collected by Prof. Beyer at Ames, and the species has been reported from the loess of Tennessee.*

PLANORBIS EXACUTUS *Say.*

Locally common in shallow ponds.

*PLANORBIS PARVUS *Say.*

Very common in ponds, etc. Rare in the western loess.

*PLANORBIS ALBUS *Muell.*

Quite rare in rather more permanent ponds. Prof Udden collected one specimen in the loess of Milan, Ill.

PLANORBIS DILATATUS *Gld.* (?).

Locally rather frequent. None fossil.

*SEGMENTINA ARMIGERA (*Say*) *H. & A. Ad.*

Common in ponds. Reported from the loess of Missouri, but not known as a fossil in Iowa and Nebraska.

ANCYLUS DIAPHANUS *Hald.*

Common on sticks, etc. in more permanent ponds.

*VALVATA TRICARINATA (*Say*).

Quite common. It also occurs in deeper ponds. Prof. Udden collected it in the loess of Milan, Ill., and it is reported from Missouri. It is, however, very rare as a fossil.

PISIDIUM COMPRESSUM *Prime* (?).

A few valves of this, or a closely related species, were found in the local loess. The species is now common, especially westward, in small prairie streamlets, etc.

All but the last two species in this list are air-breathing forms. The last one is a bivalve.

b. Species of deeper ponds, bayous, etc.

GASTEROPODS.

BITHYNELLA OBTUSA (*Lea*) *St.* Quite common.

AMNICOLA CINCINNATENSIS (*Anth.*). Very common.

*SAFFORD, *Geology of Tenn*, p. 434, 1869.

AMNICOLA LIMOSA (*Say*) *Hald.* Quite common.
VALVATA BICARINATA (*Lea*). Rather rare.

LAMELLIBRANCHS.

SPHAERIUM RHOMBOIDEUM (*Say*). *Pr.* Quite common.
CALYCULINA PARTUMEIA (*Say*). Common.
CALYCULINA SECURE (*Prime*). Not common.
CALYCULINA TRANSVERSA (*Say*). Very common.
PISIDIUM ABDITUM *Hald.* Very common.
UNIO* SUBROSTRATUS *Say.* Quite common.
ANODONTA GRANDIS *Say.* Common.
ANODONTA IMBECILLIS *Say.* Common.

c. Species of the larger creeks and the river.

GASTEROPODS.

PLEUROCERA SUBULARE (*Lea*) *Try.* Common.
SOMATOGYRUS SUBGLOBOSUS (*Say*). Common
SOMATOGYRUS INTEGER (*Say*) *Binn.*
CAMPELOMA SUBSOLIDUM (*Anth.*) *Call.* Very common.
CAMPELOMA ——— ———. Two other possible species.
LIOPLAX SUBCARINATA (*Say*) *Tros.* Not common.
ANCYLUS RIVULARIS *Say.* Very common.

LAMELLIBRANCHS.

SPHAERIUM SULCATUM (*Lam.*) *Pr.* Very common.
SPHAERIUM SOLIDULUM (*Pr.*) Quite common.
SPHAERIUM STRIATINUM (*Lam.*) *Pr.* Rather frequent.
UNIO AESOPUS *Green.* Common.
UNIO ALATUS *Say.* Common.
UNIO ANODONTOIDES *Lea.* Common.
UNIO CAPA *Green.* Rather rare.
UNIO COCCINEUS *Hild.* Common.
UNIO CORNUTUS *Barnes.* Quite common.
UNIO DONACIFORMIS *Lea.* Quite common.
UNIO EBENUS *Lea.* Rare.
UNIO ELEGANS *Lea.* Common.
UNIO ELLIPSIS *Lea.* Rather rare.
UNIO FRAGOSUS *Con.* Quite common.
UNIO GRACILIS *Barnes.* Common.
UNIO LAEVISSIMUS *Lea.* Common.
UNIO LIGAMENTINUS *Lam.* Very common.
UNIO LUTEOLUS *Lam.* Quite common.
UNIO METANEVER *Raf.* Common.
UNIO OBLIQUUS *Lam.* Not common.
UNIO ORBICULATUS *Hild.* Rare.
UNIO PARVUS *Barnes.* Common.
UNIO PLICATUS *Le S.* Very common.
UNIO PUSTULOSUS *Lea.* Very common.

UNIO RECTUS *Lam.* Common.
UNIO RUBIGINOSUS *Lea.* Not rare.
UNIO SECURIS *Lea.* Rare.
UNIO SPATULATUS *Lea.* Rarther common.
UNIO TENUISSIMUS *Lea.* Rare.
UNIO TRIGONUS *Lea.* Very common.
UNIO TUBERCULATUS *Barnes.* Very common.
UNIO VENTRICOSUS *Barnes.* Very common.
UNIO UNDULATUS *Barnes.* Quite common.
UNIO VERRUCOSUS *Barnes.* Rare.
MARGARITANA COMPLANATA *Barnes.* Common.
MARGARITANA HILDRETHIANA *Lea.* Locally common.
MARGARITANA MARGINATA *Say.* Rather rare.
MARGARIRNANA RUGOSA *Barnes.* Quite common.
ANODONTA EDENTULA *Say.* Common.
ANODONTA FERUSSACIANA *Lea.* Not rare.

Probably other species of *Anodonta* occur.

A summary of the aquatic species here listed presents the following results:

Aquatic species found here both living and fossil..............	5
Aquatic species living here and occurring in the loess elsewere.	7
Aquatic species of the occurrence of which in undoubted loess no record exists..	66
Total......	78

It will be observed that the proportion of local aquatic shells found in the loess, here or elsewhere, is comparatively insignificant, and what is true of species applies with even greater force to individuals. The fossil shells of aquatic species, with the two exceptions already noted, occur very sparingly indeed. The writer's own sets of these fossils, a part of the fruit of twenty years of careful search, form such an insignificant part of his collection that they seem scarcely worthy of serious attention. But it will be further noticed that even these aquatic fossils belong to the fauna of the small pond or streamlet which may, and often does, remain dry during the greater part of summer, and that their presence in no wise proves that large bodies of water existed where the loess was deposited. Indeed the total absence of species which are truly fluviatile, or which at least prefer larger bodies of water, would point to the contrary conclusion. These fluviatile species are today very abundant in this vicinity, and their shells are, for the most part at least, quite

heavy, and often large. Had large streams or other bodies of water existed where the loess is deposited, thus furnishing conditions favorable to this fluviatile fauna, it is reasonable to suppose that some of these shells would be found fossil today to relate the story of the conditions under which they existed. Yet no such evidence has ever been found in undoubted undisturbed loess, and the conclusion that such bodies of water did not exist where loess is now found is irresistible. Indeed the molluscan fauna of the loess points to comparatively dry, upland, terrestrial conditions such as exist over the greater part of Iowa today. It suggests land-surfaces clothed with vegetation offering shelter and food to terrestrial snails,—a vegetation developed under medium conditions of moisture and temperature such as exist here today.

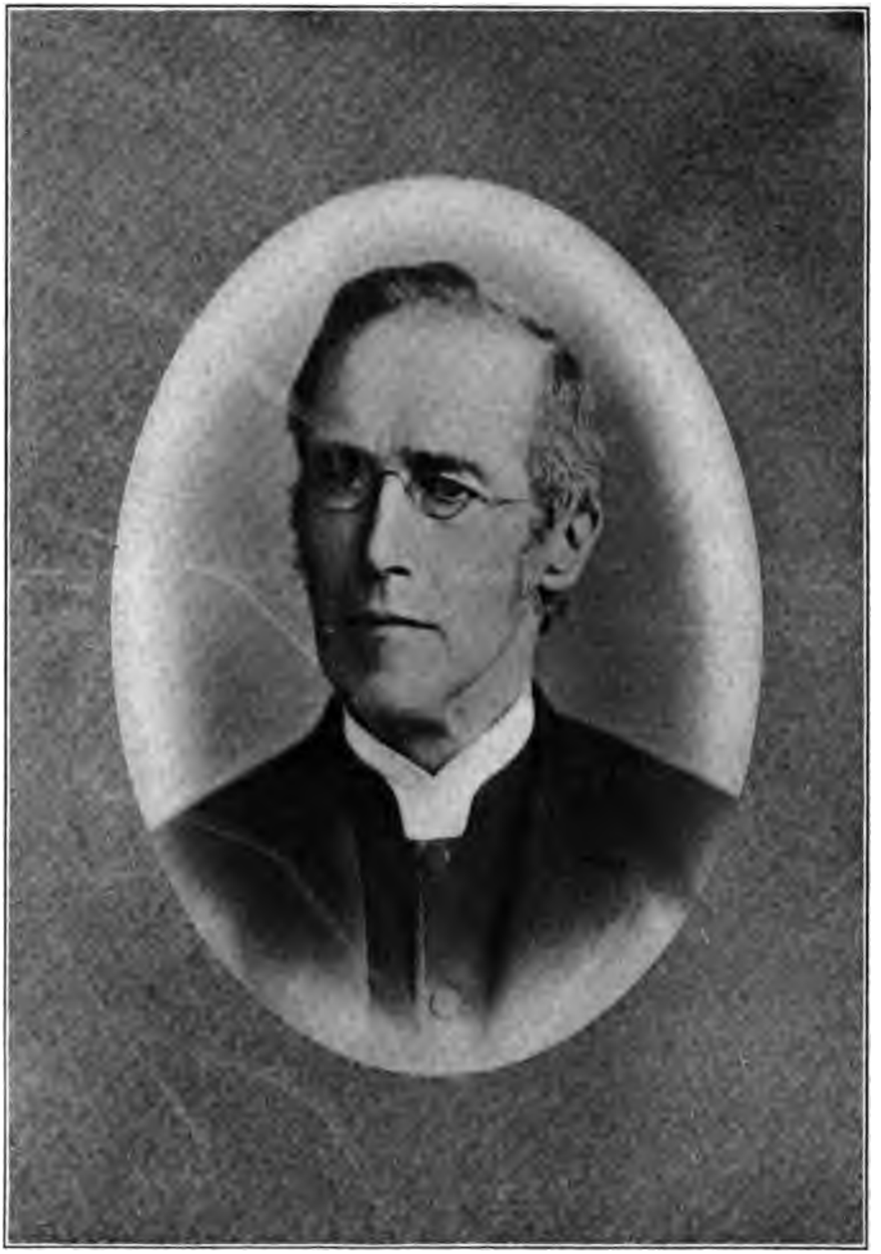
PROF. W. H. BARRIS.

By C. H. Preston, M. D.

PORTRAIT.

Willis Hervey Barris, D. D., scientist, educator and churchman, died at his home in Davenport, Iowa, June 10th, 1901, having almost completed his eightieth year. Senior priest of the Episcopal Diocese of Iowa and Curator of the Davenport Academy of Science at the time of his death, the close of a long and useful life found him still at work, as always, to the extent of his strength, in the conscientious discharge of duty.

Born in Beaver county, Pennsylvania, July 9, 1820, he entered Alleghany college, Meadville, Pennsylvania, at the age of fourteen; received the degree of A. B. in 1839, and completed a post graduate course in civil engineering in 1841. In 1854 his alma mater conferred on him the degree of A. M. His career in Alleghany college said its president, Dr. Baker, "Was equally honorable to the college and to himself." He was "an excellent scholar in every department of the college course," with a "decided penchant for scientific pursuits." At the age of twenty-one he entered upon a course of theological study and was graduated from the General Theological Seminary, New York City—the oldest Protestant-Episcopal theological school in the United States—in 1850.



Very truly yours
W. S. L. Baines

THE AMERICAN GEOLOGIST,
VOL. XXVIII. PLATE XXXIII.

Ordained priest by bishop De Lancy of New York, he became rector of St. Luke's church, Brockport, N. Y., in 1852, and later served as assistant to Rev. Henry Lee (afterward first bishop of Iowa) at Rochester, N. Y.

Coming to Iowa at the solicitation of bishop Lee, who recognized in him qualities of a high order, he became rector of Trinity church, Iowa City, in 1855, and of Christ church, Burlington, in 1859, whence, after seven years of arduous labor and study, he was called to the Ely professorship of ecclesiastical history in Griswold college, Davenport, which city was thereafter to be his home.

It was as a personal compliment to Dr. Barris, and to secure his services permanently for the college, that the Ely endowment was made and conditioned on his having a life tenure in Ely house, the home at Twelfth and Main streets, where he breathed his last. His personal popularity and recognized ability as an instructor helped largely to give to the theological department of Griswold, its high educational standing during the more than twenty years he spent in its service.

Many men, now prominent in the church, were members of his theological classes and credit him in large measure with the success attending their labors. Always modest and unassuming, himself setting the example of faithful work, he was loved and revered by his students, one of whom feelingly writes: "He was the most helpful man I ever met," "I doubt if there is one who does not bless the day that he came under the influence of the mind and heart of Willis H. Barris."

He had chosen the church as his life work and gave it his first allegiance, consequently when offered a chair in the Iowa state university, he declined, saying: "Paleontology is my play, theology is my work." Nevertheless, wherever his lot was cast, he at once identified himself with all the higher intellectual interests of the community about him, and supplemented his work for the church by a thorough study of the geology and paleontology of the region.

By numerous short excursions and occasional longer journeys, he collected material and observations which, with his scholarly interpretation, gave results of great scientific value.

At Iowa City he made a close study of the Hamilton and other Devonian rocks. At Burlington he found a rich field in the crinoids and other fossils of the Burlington limestone, of which he made a large and valuable collection, discovering many new species. Some of these are described in his own written contributions to science; others, by his permission, were named and described by Dr. Hall, Mr. Wachsmuth, Dr. Knapp and other leading geologists, who personally acknowledged the value of his work. Many of the new forms described and pictured in Wachsmuth and Springer's great work on the crinoids, were first discovered by Dr. Barris. Through Wachsmuth also, many specimens were sent to the British Museum, in acknowledgment of which a copy of the beautiful "Catalogue of the Blastoidea" (Etheridge and Carpenter, London, 1886) was sent to him by the trustees of the museum. Next to Wachsmuth, Dr. Barris is named first among the scientific friends at home and abroad to whom its authors express their indebtedness.

In the summer of 1866, professor and Mrs. Louis Agassiz visited Burlington purposely to see the Barris collection of crinoids, and were so delighted with it that negotiations were opened at once and it was purchased for the museum at Cambridge. In a subsequent letter professor Agassiz writes: "I owe it to you to say that I shall treat this collection with all the regard which it deserves, and that I shall take good care to have the scientific world know and understand that while it will become an ornament to the museum at Cambridge, it is yet entirely your work. Every specimen shall be furnished with a label stating that it once formed part of your collection, and I believe I am within bounds in saying that it will commemorate your scientific zeal and ability as surely as it would remaining in your possession. Allow me to request you, therefore, not to feel as if you had parted with your interest in science, but on the contrary to continue your efforts in a direction in which you have thus far been so eminently successful."

On removing to Davenport Dr. Barris still kept up his geological studies, contributing, from time to time, valuable articles for publication, chiefly in the Proceedings of the Davenport Academy of Science. He became a member and

was made a trustee of this institution at its first meeting, and was active in its support through life. Elected president in 1876, in 1890 he took up the work of caring for its museum and correspondence laid down by his friend, curator Pratt, and despite an affection of the eyes, at times excruciatingly painful, discharged faithfully the onerous duties of the place to within a few days of his death.

The loving regard in which he was held by his associates in the academy was thus expressed in resolutions of respect to his memory: "Of a gentle and scholarly disposition, holding close and loving communion with nature's visible forms and their informing Spirit, he had neither time nor inclination for business strife with his fellow men. The soul of kindliness in every relation of life, he made each one who came to know him a friend." To the writer, who knew him well, he embodied the highest ideal of kindly. courteous and Christian manhood. In him were united a soul pure as a child's, the modesty of great wisdom, and the simply dignity of a gentleman of the old school.

Davenport, Iowa, October 21, 1901.

A SECTION OF THE UPPER ORDOVICIAN AT VEVAY, INDIANA.

EDGAR R. CUMINGS.

PLATES XXXIV AND XXXV.

The detailed section described in the present paper is published, without the faunal lists, in a paper by the writer, in the Proceedings of the Indiana Academy of Science for 1900. It is proposed here to supplement the stratigraphic details already given, by an analysis of the faunas.*

The section begins at the level of the Ohio river at Vevay, Indiana, and includes beds ordinarily correlated with the Utica and Lorraine of the eastern United States. The lowest exposures occur at the foot of a glen or run opening out on the flood plain of the Ohio river, upon which the city of Vevay is built, at the head of "Main cross" street, just east of the orphan asylum. The section extends up the glen to near the top

*The identifications of the Bryozoa listed in this paper are invariably based upon thin sections.

of the hill. For the upper members (*Platystrophia* zone) the exposures along the road (not the toll road) over the hill back of Vevay were used. This part of the section includes fifty or more feet (zones *a* to *h*) above zone 86 of the main section.*

Section in ascending order.

No. 1. The first division, 100 feet thick, contains no exposed rock.

No. 2. Very soft blue shale at mouth of ravine. No fossils. 6 feet.

No. 3. Dark blue limestone containing *Dalmanella multisecta* Meek and *Plectambonites sericeus* Sowerby, in fair abundance. The limits of this exposure are very small. 6 inches.

No. 4. Shale, 4½ feet. There is very little variation in the character of the shale beds throughout the section.

No. 5. Limestone of the same character as number 3. 10 inches. The following fossils were collected from this layer:

1. *Coeloclema alternatum* (James).
2. *Callopora onealli-sigillaroides* (Nicholson). Very small form.
3. *Bythopora arctipora* (Nicholson).
4. *Dalmanella multisecta* (Meek).

No. 6. Shale, 4 feet.

No. 7. Limestone mottled with argillaceous spots. 5 inches.

1. *Batostoma implicatum* (Nicholson).
2. *Peronopora vera*.†
3. *Dalmanella multisecta* (Meek).

No. 8. Shale, 1 foot.

No. 9. Thin layers of fine-grained, compact limestone. 1 foot.

1. *Callopora onealli-sigillaroides* (Nicholson) (aa).
2. *Batostoma implicatum* (Nicholson) (c)§.
3. *Stictoporella* sp.
4. Ostracod indt.
5. *Cyrtolites* cf. *inornatus* (Hall).
6. *Dalmanella multisecta* (Meek).

No. 10. Shale with occasional thin uneven layers of limestone. 2 feet 3 inches.

No. 11. Limestone mottled with argillaceous material. 3 inches.

1. *Callopora onealli-sigillaroides* (Nicholson).
2. *Callopora* sp. probably *nodulosa* (Nicholson).
3. *Batostoma implicatum* (Nicholson).
4. *Peronopora vera*.

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*The main section is section 1.38A of the paper referred to above, and the upper zones (*a* to *h*) constitute the upper portion of section 1.38B of the same paper.

†A fragment labeled *P. vera* by Mr. Ulrich, in the Peabody Museum of Yale University, has been sectioned by the writer; and although the worn condition of the specimen made it impossible to get a tangental section very near the surface yet there is little question of the specific identity of the Vevay specimens and the *P. vera* of Mr. Ulrich.

§C—Common; a—abundant; aa—very abundant; aaa—so abundant as to fill the rock; r—rare; rr—a single specimen.

5. *Coeloclema alternatum* (James) (a).
6. *Bythopora arctipora* (Nicholson) (c).
7. *Leptotrypa* cf. *Calceola* (Miller & Dyer) (rr), a fragment from which the shape of the zoarium could not be made out. The internal characters are those of the species *calceola.*
8. *Dekayella ulrichi* (Nicholson) (c). Large form.
9. *Dalmanella multisecta* (Meek) (c).
10. *Plectambonites sericeus* (Sowerby).
11. *Zygospira modesta* (Hall).
12. *Calymene callicephala* (Green).
13. *Proetus* sp.
14. *Conchiolites* sp.
15. Crinoid segments of several species. (c) This layer is probably the equivalent of the base of XI *b* of Ulrich's Cincinnati section.

No. 12. Shale with occasional thin layers of limestone, 6 feet 4 inches.

No. 13. Compact limestone, 5 inches.

1. *Coeloclema alternatum* (James) (c).
2. *Bythopora arctipora* (Nicholson) (c).
3. *Callopora onealli-sigillaroides* (Nicholson)
4. *Dekayella ulrichi* (Nicholson).
5. *Arthropora* sp.
6. *Leptotrypa* sp.
7. *Callopora onealli-communis* (James).
8. *Rafinesquina alternata* (Con.).
9. *Dalmanella multisecta* (Meek).
10. *Calymene* small fragment.
11. *Zygospira modesta* Hall.
12. *Batostoma implicatum* (Nicholson).
13. Crinoid segments. *Heterocrinus?*

No. 14. Shale, 5 inches.

No. 15. Compact limestone, 6 inches.

1. *Eridotrypa vevayensis* n. sp.
2. *Dekayella obscura* Ulrich.
3. *Callopora onealli* var.
4. *Bythopora* sp.
5. *Escharopora acuminata* (James)?
6. *Dekayella ulrichi* (Nicholson).
7. *Rafinesquina alternata* (Conrad).
8. *Dalmanella multisecta* (Meek).

No. 16. Shale, 2 feet 6 inches.

No. 17. Limestone, 3 inches.

1. *Callopora onealli-sigillaroides* (Nicholson).
2. *Batostoma implicatum* (Nicholson).
3. *Peronopora vera.*
4. *Bythopora arctipora* (Nicholson).
5. *Dalmanella multisecta* (Meek).

6. *Rafinesquina alternata* (Conrad).
7. *Zygospira modesta* Hall.
8. *Plectambonites sericeus* (Sowerbv) (rr).
9. *Calymene callicephala* Green.
10. Crinoid stems.

No. 18. Shale, 7 feet.

No. 19. Thin layers of limestone, intercalated with shale, 1 foot.

1. *Peronopora vera.*
2. *Bythopora* sp.
3. *Dalmanella multisecta* (Meek) (aa).
4. *Rafinesquina alternata* (Conrad). Small form.
5. *Zygospira cincinnatiensis* (James).
6. *Dalmanella emacerata* Hall.
7. *Crania scabiosa* Hall.
8. Crinoid stems (small).

No. 20. Shale, 7 inches.

No. 21. Limestone, 3 inches.

1 *Coeloclema concentricum* (James) (aa).
2. *Callapora oncalli-sigillaroides* (Nicholson). Large Stems possibly var. *Communis.*
3. *Bythopora arctipora* (Nicholson).
4. *Dekayella ulrichi* (Nicholson).
5. *Dalmanella emacerata* Hall (c).
6. *Zygospira modesta* Hall (rr).
7. *Plectorthis* sp. (rr).
8. *Acidaspis* fragments (c).
9. *Calymene callicephala* Green.

No. 22. Shale, 2 feet 6 inches.

No. 23. Crinoidal limestone, 7 inches.

1. *Coeloclema concentricum* (James) (r).
2. *Callopora oncalli-communis* (James).
3. *Bythopora arctipora* (Nicholson) (c).
4. *Batostoma implicatum* (Nicholson).
5. *Peronopora vera* ?
6. *Dalmanella emacerata* Hall.
7. *Zygospira cincinnatiensis* Meek.
8. *Dalmanella multisecta* (Meek).
9. *Rafinesquina alternata* (Conrad).
   Fragment.
10. *Calymene callicephala* Green.
11. *Trinucleus concentricus* Eaton.
12. *Plumulites* sp.
13. Crinoid segments (aaa)
   This layer is probably the equivalent of the 120-foot level of Ulrich's section at Cincinnati.

No. 24. Shaly limestone, 5 feet 4 inches.

1. *Ceramoporella ohioensis* (Nicholson) (c).
2. ——————— *distincta* Ulrich (r).

3. *Callopora onealli-communis* (James) (c).
4. *Bythopora arctipora* (Nicholson).
5. *Coeloclema* sp. (rr).
6. *Batostoma implicatum* (Nicholson) (rr).
7. *Peronopora decipiens* (Rominger) (r).
8. *Dekayella ulrichi* (Nicholson) ?
9. *Dalmanella emacerata* Hall (r).
10. *Zygospira cincinnatiensis* Meek (r)
11. ——————*modesta* Hall (c).
12. *Acidaspis ceralepta.* Meek.
13. —————— fragment of another species.
14. *Plumulites* sp.
15. *Arthropora* sp.
16. *Calymene callicephala* Green.
17. *Asaphus* sp. fragments (c).
18. *Heterocrinus* segments.

No. 25. Dark crystalline limestone. Few identifiable fossils, 4 inches.

No. 26. Shale with thin layers of limestone, 6 feet 3 inches.

No. 27. Sandstone, 4 inches.

No. 28. Shale, 8 inches.

No. 29. Limestone with argillaceous material in spots, 7 inches.

1. *Coeloclema* fragment.
2. *Callopora* sp. probably *onealli-communis* (James).
3. *Atactoporella* sp. cf. *newportensis* or *typicalis.*
4. *Arthropora* sp.
5. *Dalamanella multisecta* (Meek) (a).
6. *Rafinesquina alternata* (Conrad). Very fine striæ.
7. *Zygospira modesta* Hall.
8. *Retzia* (?) *granulifera* Meek (rr).
9. *Anodontopsis* fragment.
10. *Acidaspis* fragments.
11. *Plumulites* sp.
12. Crinoids stems.

No. 30. Shale, 1 ft. 8 in.

No. 31. Limestone, 4 in.

1. *Coeloclema* sp.
2. *Ceramoporella ohioensis* (Nicholson).
3. *Peronopora vera.*
4. *Callopora onealli* var.
5. *Batostoma implicatum* (Nicholson).
6. *Aspidopora* sp.
7. *Heterotrypa cf. solitaria* Ulrich (rr).
8. *Escharopora acuminata* (James).
9. *Dalmanella multisecta* (Meek) (aaa).
10. *Rafinesquina alternata* (Conrad).
11. *Zygospira modesta* Hall.
12. *Trinucleus concentricus* Eaton (rr).

No. 32. Thin limestone and shale 2 ft. 4 in..

1. *Callopora onealli sigillaroides* (Nicholson).
2. *Bythopora arctipora* (Nicholson).
3. *Dekayella ulrichi* (Nicholson).
4. *Batostoma implicatum* (Nicholson).
5. *Dalmanella multisecta* (Meek.)
6. *Zygospira modesta* Hall.
7. *Rafinesquina alternata* (Conrad) (r).

No. 33. Hard limestone. Fossils nearly all fragmentary. 10 in.
1. *Callopora* sp. small form.
2. *Bythopora arctipora* (Nicholson) (c).
3. *Batostoma implicatum* (Nicholson) (rr).
4. *Dalmanella multisecta* (Meek) (aaa).
5. *Zygospira cincinnatiensis* Meek.
6. *Calymene callicephala* Green.

No. 34. Shale 2 ft.

No. 35. Bryozoal limestone 5 ft.
1. *Dekayella ulrichi* (Nicholson) (a).
2. *Dalmanella multisecta* (Meek) (aaa).
3. *Asaphus* fragments (c).

No. 36. Shale and thin limestones, 2 ft. 6 in.

No. 37. Bryozoal limestone in thin layers. 2 feet, 6 inches.
1. *Dekayella ulrichi* (Nicholson) (aa).
2. *Coeloclema concentricum* (James) (a).
3. *Leptotrypa clavis* Ulrich (r).
4. *Callopora oncalli* (James) var.
5. ——— ——— *communis* (James).
6. *Batostoma implicatum* (Nicholson). ?
7. *Zygospira cincinnatiensis* Meek. ?
8. *Zygospira modesta* Hall.
9. Crinoid segments (aa).

No. 38. Shale 5 ft.

No. 39. Crinoidal limestone, 8 in.
1. *Callopora onealli-communis* (James).
2. *Dekayella ulrichi* (Nicholson) (c).
3. Crinoid segments (aaa).

No. 40. Shale 3 ft.

No. 41. Limestone, 2 in.
1. *Batostoma* sp.
2. *Dekayella ulrichi* (Nicholson) (c).
3. *Callopora oncalli-communis* (James).
4. *Bythopora arctipora* (Nicholson).
5. *Asaphus* fragments.
6. Crinoid segments.

No. 42. Shale 3 ft.

No. 43. Layers of calcareous sandstone, 6 in.

No. 44. Shale, 2 ft. 3 in.

No. 45. Thin layers of limestone, 5 ft.
1. *Coeloclema* sp.

2. *Peronopora decipiens* (Rominger).
3. *Callopora onealli-communis* (James).
4. *Bythopora arctipora* (Nicholson) (r).
5. *Ceramoporella ohioensis* (Nicholson).
6. *Dekayella ulrichi* (Nicholson).
7. *Arthropora* sp.
8. *Zygospira cincinnatiensis* Meek.
9. *Dalmanella multisecta* (Meek).
10. *Zygospira modesta* Hall.

No. 46. Shale 2 ft.

No. 47. Yellowish limetsone, 3 in.

No. 48. Shale, 1 ft.

No. 49. Coarse-grained limestone, 6 in.

1. *Coeloclema* sp.
2. *Arthropora* sp.
3. *Acidaspis* sp.
4. *Callopora onealli* var.
5. *Dalmanella multisecta* (Meek) (aaa).
6. *Rafinesquina alternata* (Conrad) (c).

No. 50. Shale 2 ft. 8 in.

No. 51. Gray limestone, 3 in.

1. *Rafinesquina alternata* (Conrad) fragments (aa).
2. *Dekayella ulrichi* (Nicholson) (c).

No. 52. Shale, 10 in.

No. 53. Limestone, 3 in.

1. *Rafinesquina alternata* (Conrad) fragments (c).
2. *Dalmanella emacerata* Hall (r).
3. Crinoid segments (c).

No. 54. Shale, 6 in.

No. 55. Coarse-grained crystalline limestone, fragments of *Dalmanella multisecta* and *Rafinesquina alternata* abundant, 6 in

No. 56. Covered. Probably limestone, 25 ft.

No. 57. Compact limestone *Dalmanella multisecta* abundant, 7 in.

No. 58. Covered. 2 ft.

No. 59. Dark drab limestone, 4 in.

1. *Peronopora decipiens* (Rominger). Large form; very thick cell walls, numerous mesopores and acanthopores.
2. *Dekayella ulrichi* (Nicholson).
3. *Callopora onealli* var.
4. *Dalmanella multisecta* (Meek.)
5. *Rafinesquina alternata* (Conrad) fragments.
6. *Zygospira modesta* Hall.

No. 60. Covered, 8 ft., 8 in.

No. 61. Limestone, 1 ft., 2 in.

1. *Callopora* cf. *ramosa* or *dalei.*
2. *Dalmanella multisecta* (Meek) (aaa).

No. 62. Covered, 8 in.

No. 63. Bryozoal limestone, 6 in.

1. *Dekayella ulrichi* (Nicholson).
2. *Callopora* cf. *ramosa* (d'Orbigny).
3. *Zygospira modesta* Hall.
4. *Platystrophia biforata* (Schlotheim).
Very small imperfect specimens, nearest to var. *dentata.*

Base of platystrophia zone.

No. 64. Covered, 6 ft.

No. 65. Thin-bedded bryozoal limestone, 8 ft.
1. *Callopora ramosa* (d'Orbigny). ?
2. *Dekayella ulrichi robusta* Foord.
3. *Platystrophia biforata* (Schlotheim). Small form, nearest to *dentata.*
4. *Herbertella occidentalis sinuata* Hall.

No. 66. Thicker-bedded, light gray limestone, containing fragments of *Rafinesquina alternata* in abundance. *Zygospira modesta* common, 1 foot.

No. 67. Covered, 1 foot 8 inches.

No. 68. Coarse grained limestone. *Rafinesquina alternata* abundant, 5 inches.

No. 69. Shale, 6 inches.

No. 70. Fine-grained limestone, containing *Zygospira modesta* Hall. 3 inches.

No. 71. Covered, 3 feet.

No. 72. Coarse-grained, crinoidal limestone. *Refinesquina alternata* common, 4 inches.

No. 73. Limestone, 1 foot 3 inches.
1. *Platystrophia biforata* (Schlothem). Small form with 17 plications (the normal number) on the ventral valve.
2. *Rafinesquina alternata* (Conrad). Very thin form.
3. *Escharopora pavonia* (d'Orbigny).
4. *Constellaria constellata* (Van Cleve). Large specimens.
5. *Batostoma* sp., probably new.

No. 74. Coarse-grained limestone, 3 to 8 inches.

No. 75. Covered, 6 inches.

No. 76. Compact limestone. *Rafinesquina* common, 4 inches.

No. 77. Covered, 3 feet 8 inches.

No. 78. Limestone with *Rafinesquina* and Bryozoa, 5 inches.

No. 79. Argillaceous-arenaceous, thin imestone. Some covered, 14 feet.

No. 80. Argillaceous-arenaceous limestone, 4 inches.

No. 81. Covered, 3 feet 3 inches.

No. 82. Yellow sandstone, 4 inches.

No. 83. Thin irregular limestone, 6 inches.
1. *Platystrophia biforata* (Schl.)
2. *Constellaria constellata* (Van Cleve).

No. 84. Thin-bedded limestone containing *Platystrophia biforata* (Schl.).

No. 85. Yellow argillaceous sandstone, 4 inches.

No. 86. Limestone with *Platystrophia* and *Hebertella sinuata*, 6 feet.

The remainder of the Platystrophia beds is, as stated above, from the exposures along the road a short distance from the upper exposures of the section just described. The zone which is here 40 to 50 feet thick is divided arbitrarily into eight equal sub-zones for the purposes of analysis of the faunas. These sub-zones are lettered *a* to *h* from the base up. Lithologically they vary but little, there being somewhat more sandy material in the lower layers and a greater percent. of argillaceous material further up in the section. All the layers are very thin and irregular and easily disintegrated constituting on the whole an extremely *shaly* limestone.

The faunas of these sub-zones are as follows:

Zone A:

1. *Homotrypa curvata* Ulrich (aa).
2. *Ceramoporella ohioensis* (Nicholson).
3. *Peronopora decipiens* (Rominger).
4. *Dekayia* sp.
5. *Heterotrypa inflecta* Ulrich.
6. *Dekayia aspera* E. & H.
7. *Callopora subplana* Ulrich.
8. *Callopora rugosa* (E. & H.). ?
9. *Bythopora* sp.
10. *Escharopora pavonia* (d'Orbigny).
11. *Escharopora falciformis* (Nicholson).
12. *Platystrophia biforata-lynx* (Eichwald).
13. *Platystrophia biforata-dentata* Meek.
14. *Rafinesquina alternata* (Con.).
15. *Plectorthis plicatella* Hall.
16. *Hebertella occidentalis-sinuata* Hall.
17. *Acidaspis* sp.
18. *Heterocrinus* sp.
19. *Cyclora minuta* Hall.

Zone B:

1. *Ceramoporella ohioensis* (Nicholson) (c).
2. *Bythopora delicatula* (Nicholson).
3. *Callopora rugosa* (E. & H.).
4. *Escharopora pavonia* (d'Orbigny).
5. *Monticulipora mammulata* (d'Orbigny).
6. *Escharopora falciformis* (Nicholson).
7. *Constellaria constellata* (Van Cleve) Dana.
8. *Petigopora asperula* Ulrich.
9. *Rafinesquina alternata* (Con.) typical (a).
10. *Zygospira modesta* Hall (a)
11. *Hebertella occidentalis-sinuata* Hall (c).
12. *Plectorthis plicatella* Hall.

13. *Platystrophia bioforata-lynx.* (Eichw.).
14. *Megambonia jamesi* Meek.
15. *Modiolopsis modiolaris* (Conrad) (c)
16. *Cyclonema bilix* (Conrad).
17. *Asaphus* sp.
18. Crinoid segments (c).
19. *Calymene callicephala* Green.

Zone C:

1. *Heterotrypa frondosa* (d'Orbigny).
2. *Nicholsonella vaupeli* (Ulrich) (c).
3. *Monticulipora molesta* Nicholson.
4. *Ceramoporella ohioensis* (Nicholson).
5. *Petigopora asperula* Ulrich.
6. *Escharopora falciformis* (Nicholson).
7. *Crania scabiosa* Hall.
8. *Zygospira modesta* Hall.
9. *Platystrophia biforata-lynx* (Eichw.).
10. *Platystrophia biforata laticosta* (Meek).
11. *Plectorthis plicatella* Hall.

Zone D:

1. *Amplexopora filiosa* (d'Orbigny).
2. *Heterotrypa frondosa* (d'Orbigny).
3. *Dekayia* sp.
4. *Callopora ramosa* (d'Orbigny).
5. *Escharopora falciformis* (Nicholson).
6. *Petigopora asperula* Ulrich.
7. *Ceramoporella* sp.
8. *Hebertella occidentalis-sinuata* Hall.
9. *Zygospira modesta* Hall.
10. *Rafinesquina alternata-fracta* (Meek).

Zone E:

1. *Callopora rugosa* (E. & H.).
2. *Petigopora asperula* Ulrich.
3. *Ceramoporella ohioensis* (Nicholson).
4. *Escharopora falciformis* (Nicholson).
5. *Heterotrypa frondosa* (d'Orbigny).
6. *Peronopora decipiens* var.
7. *Monticulipora molesta* Nicholson.
8. *Bythopora delicatula* (Nicholson).
9. *Bythopora gracilis* (Nicholson).
10. *Petigopora petechialis* (Nicholson).
11. *Atactoporella* sp.
12. *Proboscina auloporoides* (Nicholson).
13. *Rafinesquina alternata* (Con.) (c).
14. *Hebertella occidentalis-sinuata* Hall (a).
15. *Platystrophia biforata-lynx* (Eichw.).
16. *Zygospira modesta* Hall (aaa).
17. *Rafinesquina alternata-nasuta* (Con.).

18. *Cyclora minuta* Hall.
19. *Crania scabiosa* Hall.
20. *Conchiolites* sp.

Zone F:

1. *Callopora ramosa* (d'Orbigny) (c).
2. *Callopora rugosa* (E. & H.) (c).
3. *Bythopora delicatula* (Nicholson).
4. *Petigopora petechialis* (Nicholson).
5. *Ceramoporella ohioensis* (Nicholson).
6. *Monticulipora molesta* (Nicholson).
7. *Peronopora decipiens* (Rominger).
8. *Hebertella occidentalis-sinuata* Hall (aa).
9. *Platystrophia biforata-laticosta* (Meek) (aa).
10. *Platystrophia biforata-lynx* (Eichw.).
11. *Rafinesquina alternata-fracta* (Meek).
12. *Zygospira modesta* Hall.
13. *Plectorthis plicatella* Hall.
14. *Megambonia* sp.
15. *Calymene callicephala* Green.

Zone G:

1. *Callopora rugosa* (E. & H.).
2. *Bythopora* cf. *delicatula* (Nicholson).
3. *Platystrophia biforata-lynx* (Eichw.). (aa).
4. *Hebertella occidentalis-sinuata* Hall (aa).
5. *Rafinesquina alternata-ponderosa.** (aa).
6. *Plectorthis* sp. probably *plicatella.*
7. *Zygospira modesta* Hall.
8. *Crania scabiosa* Hall.

Zone H:

1. *Heterotrypa prolifica* Ulrich (c).
2. *Nicholsonella vaupeli* (Ulrich) (aa).
3. *Ceramoporella ohioensis* (Nicholson).
4. *Peronopora decipiens* (Rominger) (c).
5. *Monticulipora molesta* (Nicholson) (a).
6. *Bythopora gracilis* (Nicholson) (c).
7. *Homotrypa curvata* Ulrich. ?
8. *Heterotrypa frondosa* (d'Orbigny).
9. *Callopora rugosa* (E. & H.)
10. *Callopora ramosa* (d'Orbigny).
11. *Heterotrypa inflecta* Ulrich. ?
12. *Petigopora petechialis* (Nicholson).
13. *Bythopora delicatula* (Nicholson) (a).
14. *Petigopora asperula* Ulrich.
15. *Petigopora* sp., form with diaphragms ad large acanthopores.
16. *Spatiopora maculosa* Ulrich.

*This name "used by collectors" has no technical standing, but might very well be adopted for the massive thick shelled *rafinesquinas* occurring so abundantly in the "lynx" beds.

17. *Proboscina auloporoides* (Nicholson).
18. *Platystrophia bifrata-lynx* (Eichw.).
19. *Platystrophia biforata-laticosta* (Meek).
20. *Hebertella occidetanlis-sinuata* Hall.
21. *Zygospira modesta* Hall.
22. *Rafinesquina alternata-ponderosa.*
23. *Rafinesquina alternata-nasuta.* (Con.).
24. *Crania scabiosa* Hall.
25. *Conchiolites* sp.
26. *Cyrtolites inornatus* Hall.
27. *Megambonia jamesi* Meek.

In addition to the species in the above lists, a miscellaneous collection from zones ***a*** to ***h***, inclusive, contains the following species:

1. *Heterotrypa paupera* (Ulrich)
2. *Dekayia magna* n. sp.
3. *Dekayella cystata* n sp.
4. *Amplexopora septosa* (Ulrich).
5. *Dekayia pelliculata* Ulrich.
6. *Callopora andrewsi* (Nicholson).
7. *Homotrypa obliqua* Ulrich.
8. *Batostoma varians* (James) ?
9. *Proboscina frondosa* (Nicholson).
10. *Trematis* sp.
11. *Beyrichia chambersi* ?
12. *Stomatopora inflata* (Hall).
13. *Plectorthis ella* Hall.
14. *Orthocreas* sp.

It is of interest to compare this section with that of Ulrich* at Cincinnati, especially since the latter is the type section for this part of the Upper Ordovician of the Ohio valley.

These two sections (Cincinnati and Vevay) may be tabulated as follows:

TABULATION OF ULRICH'S SECTION AT CINCINNATI.

430′	....	*Platystrophia lynx* and numerous bryozoa.	XII b.
	30′		
400′	....	*Callopora ramosa, C, rugosa, Bythopora gracilis, Heterotrypa inflecta, Peronopora compressa, Dekayia appressa, etc., Ambonychia jamesi, etc.*	
	15′		
385′	....	*Strophomena nasuta.*	
	15′		
370′	....	*Strophomena ponderosa.*	
	10′		
360′	....	*Atactoporella mundula, Constellaria constellata, Leptotrypa discoidea, Escharopora pavonia, Plectorthis plicatella. P. ella, Cyclonema bilix, Platystrophia crassa, Anodontopsis unionoides.*	XII a.
	50′		

*AM. GEOL., vol. i, pp. 305-315; vol. ii, pp. 39-44.

310′		*Strophomena planoconvexus.*	XII a.
	25′	Fossils rare. Worn specimens of *Orthis testudinaria.*	
285′		*Homotrypa curvata, Dekayia aspera, Heterotrypa frondosa.*	
	20′		
265′		*Callopora dalei, C. subplana, Peronopora vera.*	
	5′		
260′		Reappearance of *Dekayella* fauna.	
	80′		
180′		*Callopora sigillaroidea* (large form), *Constellaria constellata* var. *prominens.*	XI b.
	60′	Zone of *Dekayella uirichi, D. Obscura, Batostoma jamesi, B. implicatum, Callopora sigillaroidea, Cœloclema alternatum, C. concentricum, Dallmanella multisecta, etc.*	
120′		*Trinucleus concentricus* and *T. bellulus.*	
	40′		
80′			
	20′	Nearly barren.	
60′		Zone of *Leptobalus insignis, Triarthrus, becki, etc.*	
	10′		
50′			XI a.
	50′		
0		Low water level of Ohio river at Cincinnati.	

Tabulation of Section at Vevay.

357′		*Platystrophia lynx* (aa) (zone *h*). *P. laticosta, etc.*	Zone of *Platystrophia biforata.* Zones XII *a* and XII *b* of Ulrich.
	55′	Zone *a* to *h.* *Monticulipora molesta, Heterotrypa frondosa, H. prolifica* (near top), *H. inflecta, Callopora rugosa, C. ramosa, Nicholsonella vaupeli, Rafinesquina fracta, R. nasuta, R. ponderosa. Hebertella sinuata, Plectorthis plicatella, Platystrophia laticosta, etc.*	
302′		*Callopora subplana, Homotrypa curvata, Dekayia aspera* (zone *a*).	
	12′		
290′		*Platystrophia bilorata, Constellaria constellata.*	
	30′		
260		*Constellaria constellata, Escharopora pavonia, Platystrophia laticosta,* (No. 73.)	
	20′		
240		*Platystrophia biforta* (small), *Dekayella ulrichi* (No. 63), lowest specimens of *Platystrophia.*	
	44′	*Rafinesquina alternata* very abundant, *Dalmanella multisecta* abundant.	Zone of *Dalmanella multisecta.* XI *b* of Ulrich.
196′			
	6′		
190′		*Callopora onealli-communis* abundant.	
	46′	Zone of *Dekayella ulrichi,* etc., *Dalmanella multisecta, etc.,* (Nos. 3 to 49).	
144′		*Trinucleus concentricus* (No. 23).	
	44′		
126′		*Dekayella ulrichi, Batostoma implicatum, Callopora sigillaroides, Cœloclema alternatum, etc.* (No. 11).	
	20′		

101′	..........101′	**Base of exposed section.** ***Dalmanella multisecta, Plectambonites sericeus.*** **(No. 3).**	**Lower *Plectambonites sericeus* Zone. XI *a* of Ulrich in part.**
0	....	**Level of Ohio river at Vevay.**	

The correspondences between these two sections are too apparent to need further emphasis. Numbers 3 to 49 of the Vevay section have an aggregate thickness of approximately 96 feet. The same zones in the Cincinnati section have an aggregate thickness of about 100 feet. *Trinucleus concentricus* comes in at almost exactly the same level in both sections. Number 63 of the Vevay section is probably to be correlated with the 260 foot level of the Cincinnati section and number 45 with the 180 foot level of the latter. Number 73 is *not* the equivalent of Ulrich's 180 foot level. *Constellaria constellata* ranges through a considerable thickness of rocks.

Numbers *a* to *h* of the Vevay section seem to be equivalent to all above the 285 foot level of the Cincinnati section; though the unexposed portions of the Vevay section may conceal a zone of *Homotrypa curvata* between numbers 55 and 83. Certain it is that this well characterized species occurs abundantly in zone *a,* though not above it. If it is true that these *Homotrypa* zones are equivalent, then the beds XII *a* of Ulrich's section are to a large degree suppressed in the Vevay section.

It remains to discuss certain peculiarities in the range of several species.

Callopora onealli sigillaroides occurs in the lowest layers as a very small form and increases in size but without alteration of internal characters as higher layers are reached passing apparently into the variety *communis* of James, a form occurring in large masses and prodigious numbers in some of the higher zones.

Dekayella ulrichi seems to experience a similar progressive increase in size the variety *robusta* occurring in beds well up in the series.

Dalmanella multisecta occurs in nearly every limestone layer up to the base of the *Platystrophia* zone; and numbers 3 to 61 inclusive may with great propriety be called the *Dalmanella multisecta* zone. Where this species occurs abundantly the

young stages can usually be obtained. Specimens in the writer's collection, of a width of less than 1 mm., and even so small as 0.5 mm. are not infrequent. These together with similar developmental material from the zone of *Dalmanella meeki* higher up in the series await description in another place.

Platystrophia biforata and its varieties has been discussed in detail in a paper by Mr. Mauck and the writer on a quantitative study of variation in this species. There could scarcely be a better locality than Vevay for the collection of adequate series of this interesting species, and especially of the so-called variety *lynx*.

Rafinisquina alternata also exhibits minute variations from zone to zone culminating in the form *ponderosa* of the *lynx* beds. This protean species would well repay quantitative study and here again Vevay would readily furnish suitable material.

DESCRIPTION OF NEW SPECIES.

Dekayia magna, n. sp.

PLATE XXXIV, FIGS. 1 TO 6.

In form and general appearance ths species closely resembles *D. aspera* E. & H. The zoarium consists of irregular flattened branches (as in the Lawrenceburg specimen) or more frequently of robust frequently branching masses (as in the Vevay specimen) of a diameter of 40 mm. or more. Spines can occasionally be detected upon the surface.

Tangental sections show that the cell walls are thin with usually a well defined median lamina. Acanthopores few, *small.* Diaphragms extremely few; occasionally one or two near the surface.

Observation: This form might be considered as identical with *D. aspera* but for the small size and less frequency of the acanthopores.

Locality: Vevay and Lawrenceburg, Indiana, in the *Platystrophia laticosta* zone.

Dekayella cystata, n. sp.

PLATE XXXV, FIGS. 1 TO 6A.

Zoarium consisting of flattened branches, at times 30 mm. or more in width. Surface covered with small conical monticules, about three in the space of 5 or 6 mm. Cells 0.2 mm. to

0.15 mm. in diameter. The monticules are composed of groups of cells larger than the average interspersed with a greater or less number of very minute cells (mespores). The latter are practically confined to the regions of the monticules.

Tangental sections reveal the characteristic cell structures of the genus, with the large and small sets of acanthopores.

Longitudinal sections show numerous diaphragms about one-half cell diameter apart in the large cells and much more numerous in the mesopores. A peculiarly characteristic thing is the presence of an occasional cystiphragm, especially near the surface.

Observation: This species might easily be mistaken for *Heterotrypa subpulchella* from which it differs in the two sets of acanthopores and the presence of curved diaphragms.

Locality: Veray in the *Platystrophia lynx* beds.

Amplexopora multispinosa, n. sp.

PLATE XXXIV, FIGS. 7 to 10.

Zoarium consisting of frequently branching cylindrical or sub-cylindrical stems of an average diameter of from 8 to 10 mm. Surface with inconspicuous maculæ. Cells of average size about 0.2 mm. in diameter.

In longitudinal sections the cells are seen to be thin walled in the axial region and without diaphragms. They bend somewhat abruptly toward the surface, becoming greatly thickened and at the same time developing in the passage from the immature to the mature region a considerable number of diaphragms many of which are curved or even coalesce giving the false appearance of cystiphragms. Near the surface, diaphragms are again lacking.

In tangental sections, cutting the mature region, the cell-walls are thick, with very clearly defined true walls thickly interspersed with small acanthopores and covered by a copious deposit of secondary schlerenchyma.

Localiqy: Associated with *Callopora communis* in the upper*Dalmanella multisecta* beds, at Vevay and Milton, Indiana.

Eridotrypa vevayensis, n. sp.

PLATE XXXV, FIGS. 7 AND 8.

The zoarium of this species cannot be described owing to the fact that all the specimens seen were fragments imbedded in the limestone matrix. It is however of small size.

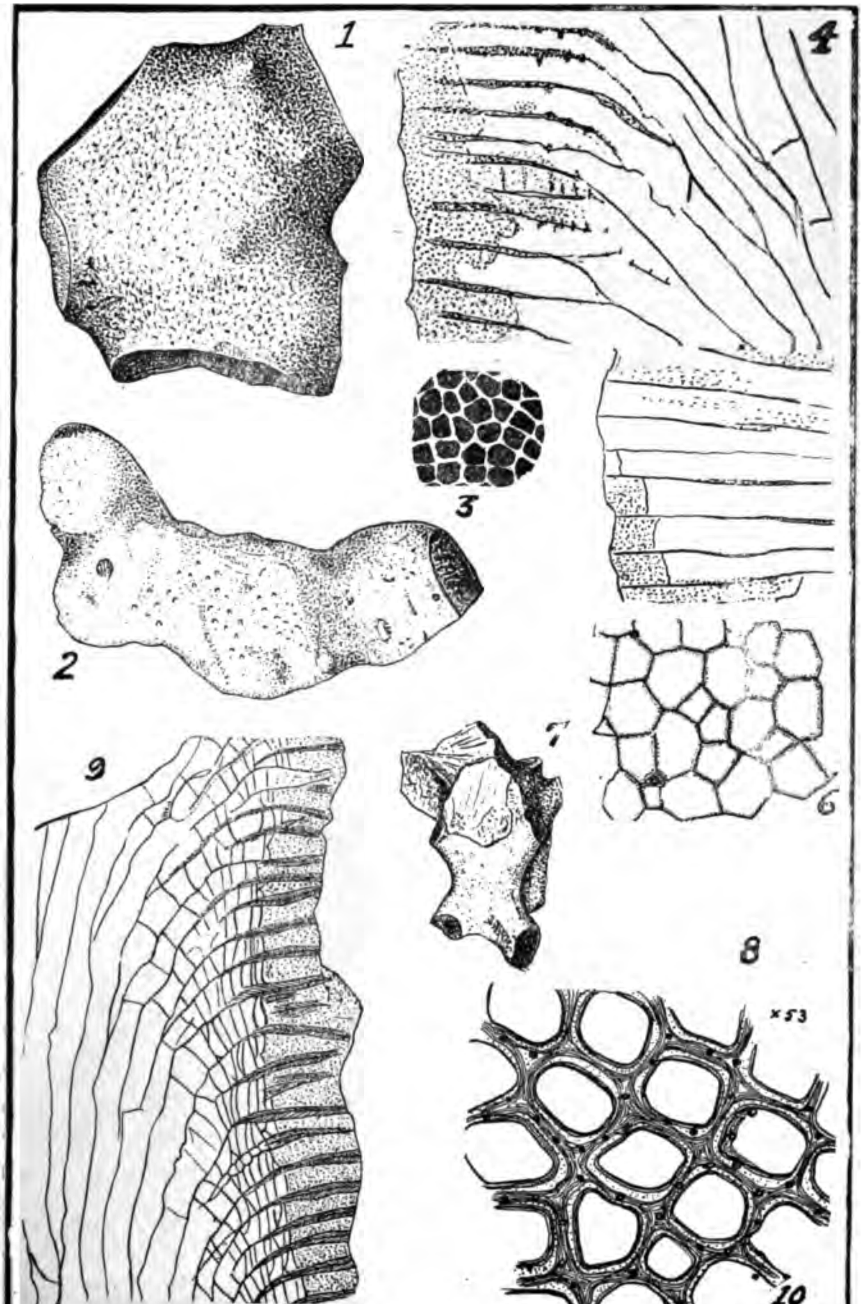
Internally the species is seen in tangental and longitudinal sections to possess a structure closely similar to that of *E. briareus* (Nicholson sp.), from which it differs in the presence in fair abundance of mesopores and in the general obliquity of the diaphragms. The latter are more numerous in the mesopores.

Locality: Vevay, Indiana, in the *Dalmanella multisecta* zone, associated with *Dekayella obscura* and *Callopora onealli*: Also at a similar level in the Kentucky bank of the Ohio near Lawrenceburg, Indiana.

Yale University, Oct., 1901.

[illegible]

[illegible]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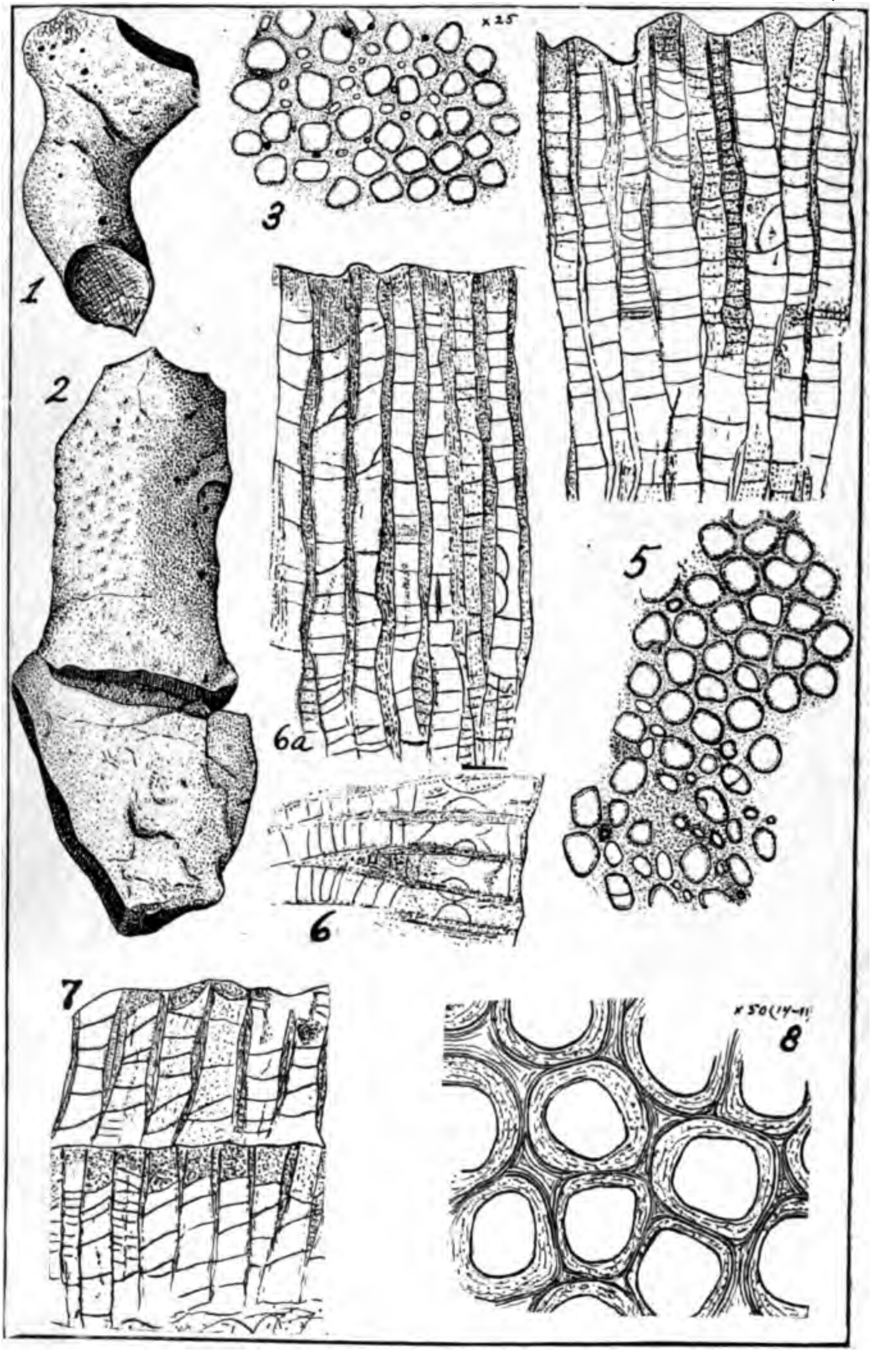
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8

TABLE SHOWING THE DISTRIBUTION OF SPECIES

	BRYOZOA.	3	5	7	9	11	13	15	17	19	21	23	24	29	31	32
1	*Callopora oncalli* (James) var.							x								
2	*Callopora oncalli sigillaroides* (Nicholson)		x		x	x	x	x	x		x	x	x			x
3	*Callopora oncalli communis* (James)					x	x	x			x	x	x	x	x	
4	*Callopora nodulosa* (Nicholson)					?										
5	*Callopora ramosa* (d'Orbigny)															
6	*Callopora rugosa* (Edwards & Haimé)															
7	*Callopora subplana* Ulrich															
8	*Callopora andrewsi* (Nicholson)															
9	*Peronopora vera*		x		x				x	x		?			x	
10	*Peronopora decipiens* (Rominger)															
11	*Peronopora decipiens* var.															
12	*Batostoma implicatum* (Nicholson)				x	x	x		x			x	x		x	x
13	*Batostoma jamesi* (Nicholson)			?												
14	*Amplexopora multispinosa* n. sp.												—	—	—	—
15	*Batostoma varians* (James)															
16	*Batostoma* sp.						x									
17	*Leptotrypa calceola* (Miller & Dyer)					x										
18	*Leptotrypa clavis* Ulrich															
19	*Leptotrypa* sp.						x									
20	*Bythopora arctipora* (Nicholson)		x			x	x	x	x	x	x	x	x			x
21	*Bythopora delicatula* (Nicholson)															
22	*Bythopora gracilis* (Nicholson)															
23	*Bythopora meeki* (James)															
24	*Coeloclema alternatum* (James)		x			x	x									
25	*Coeloclema concentricum* (James)										x		x			
26	*Coeloclema* sp.													x	x	
27	*Dekayella ulrichi* Nicholson					x	x	x			x		x		x	
28	*Dekayella ulrichi robusta* Foord															
29	*Dekayella obscura* Ulrich							x								
30	*Dekayella cystata* n. sp.															
31	*Arthropora* sp.						x						x	x		
32	*Escharopora pavonia* (d'Orbigny)							?								
33	*Escharopora falciformis* (Nicholson)															
34	*Escharopora acuminata* (James)														x	
35	*Eridotrypa vevayensis* n. sp.							x								
36	*Ceramoporella ohioensis* (Nicholson)												x		x	
37	*Ceramoporella distincta* Ulrich												x			
38	*Atactoporella typicalis* Ulrich ?													x		
39	*Atactoporella ortoni* (Nicholson)															
40	*Aspidopora* sp.														x	
41	*Heterotrypa solitaria* Ulrich														?	
42	*Heterotrypa frondosa* (d'Orbigny)															
43	*Heterotrypa inflecta* Ulrich)															
44	*Heterotrypa paupera* (Ulrich)															
45	*Heterotrypa prolifica* (Ulrich)															
46	*Nicholsonella vaupeli* (Ulrich)															
47	*Constellaria constellata* (Van Cleve)															
48	*Dekayia aspera* Edwards & Haimé															
49	*Dekayia pelliculata* Ulrich															
50	*Dekayia magna* n. sp.															
51	*Petigopora petechialis* (Nicholson)															
52	*Petigopora asperula* Ulrich															
53	*Monticulipora mammulata* d'Orbigny															
54	*Monticulipora molesta* Nicholson															
55	*Amplexopora filiosa* (d'Orbigny)															
56	*Amplexopora septosa* (Ulrich)															
57	*Homotrypa curvata* Ulrich															
58	*Homotrypa obliqua* Ulrich															
59	*Spatiopora maculosa* Ulrich															
60	*Stomatopora arachnoidea* (Hall)															
61	*Stomatopora inflata* (Hall)															
62	*Proboscina auloporoides* (Nicholson)															
63	*Proboscina frondosa* (Nicholson)															
	BRACHIOPODA.															
64	*Dalmanella multisecta* Meek	x	x	x	x	x	x	x	x	x		x		a	aaa	a
65	*Dalmanella emacerata* Hall									x	x	x	x			
66	*Plectambonites sericeus* (Sowerby)	x				x										
67	*Rafinesquina alternata* (Conrad)					x	x	x	x	x		x		a	x	x
68	*Rafinesquina alternata nasuta* (Conrad)															
69	*Rafinesquina alternata fracta* (Meek)															
70	*Rafinesquina alternata ponderosa*															
71	*Zygospira modesta* Hall					x	x		x		x	x	x	x	x	x
72	*Zygospira cincinnatiensis* Meek									x		x	x			

IN THE VEVAY SECTION (NUMBERS REFER TO ZONES.)

33	35	37	39	41	45	49	51	53	55	59	61	63	65	73	83	a	b	c	d	e	f	g
		x																				
x		x																				
											x		x									
																			x		x	
																	x			x	x	x
																x						
																x					x	
																				x		
x		x																				
		x																				
x				x																		
																?	?			x	x	x
		x																				
	x	x	x	x	x	x	x	x		x		x										
												x										
					x	x																
																x	x					
																x	x	x	x			
					x											x	x	x	x	x	x	
																		x	x	x		
																	x					
																		x				
														x			x					
																	x					
																				x	x	
																	x	x	x	x		
																x						
																		x		x	x	
																			x			
																x						
																						?
																				x		
aaa	aaa				x	aaa				x	aaa											
								x														
						c	a	x		x				x		x	x			x	x	
																				x		
																			x			
																						a
		x			x					x		x					a	x		aa	aa	x
x		?			x																	

TABLE SHOWING THE DISTRIBUTION OF SPECIES IN THE

	3	5	7	9	11	13	15	17	19	21	23	24	29	31	32
73 *Platystrophia biforata* (Schlotheim)															
74 *Platystrophia biforata denata* (Pander)															
75 *Platystrophia biforata laticosta* (Meek)															
76 *Platystrophia biforata lynx* (Eichwald)															
77 *Hebertella occidentalis sinuata* Hall															
78 *Plectorthis plicatella* Hall															
79 *Plectorthis ella*															
80 *Plectorthis* sp.										x					
81 *Retzia granulifera* (Meek)													?		
82 *Trematis* sp.															
TRILOBITA.															
83 *Calymene callicephala* Green					x			x		x	x	x			
84 *Proetus* sp. indt.					x										
85 *Acidaspis ceralepta* Meek												x	x		
86 *Acidaspis* sp.												x	x		
87 *Acidaspis* sp.										x		x			
88 *Trinucleus concentricus* Eaton											x		x		
CIRRIPEDIA.															
89 *Plumulites* sp.											x			x	
PELECYPODA.															
90 *Anodontopsis* sp													x		
91 *Megambonia jamesi* Meek															
GASTROPODA.															
92 *Cyclora minuta* Hall															
93 *Cyrtolites inornatus* Hall				x											
94 *Cyclonema biliæ* (Conrad)															

THE CLEVELAND WATER SUPPLY TUNNEL.

By S. J. PIERCE, Cleveland, Ohio.

Since 1896, the city of Cleveland, Ohio, has been engaged in constructing a new water-works tunnel under lake Erie, for the purpose of securing a sufficient and better supply of water. During the construction of this tunnel the geological features have been noted from time to time. These observations, with the records of an older tunnel, are here presented to the AMERICAN GEOLOGIST. The object of this paper is to present the observations made and results shown, without in any way touching on theoretical ground.

THE TUNNEL.

The new tunnel commences on the east side of the river mouth about two and one half miles east of the Public Square, and extends in a northwest direction under the lake. Its length, from the shore to the permanent steel intake crib is 26,000 feet,—a trifle short of five miles.

The bottom of the tunnel is 100 feet below the lake level at the shore, and 110 feet below at the intake crib. This gives a slope of two feet per mile to lakeward. The depth

VEVAY SECTION (NUMBERS REFER TO ZONES.)—*Continued.*

33	35	37	39	41	45	49	51	53	55	59	61	63	65	73	83	a	b	c	d	e	f	g
												x										
													x			x						
														x	x			x			x	
																x	x	x		x	x	x
													x			x	x			x	x	x
																x	x	x				
x																	x				x	
	x			x													x					
																	x				x	
																x				x		
																	x					

of water at the shore is thirty-seven feet; and at the lake end, fifty-seven feet. The tunnel is nine feet in diameter in the clear, and is lined throughout with three courses of brick. Two temporary cribs were sunk in the lake over the line of the tunnel to facilitate the construction, the work progressing in each direction from the cribs and from the shore.

The construction of this tunnel was begun in October, 1896, and it is expected to be completed about a year from the present time. Its capacity will be 175,000,000 gallons in twenty-four hours.

THE GEOLOGICAL FEATURES.

The entire length of the tunnel has been in a sedimentary deposit of very fine stratified blue clay. This seems to be of similar formation to the clay forming the bluffs along lake Erie, and which has been named by Newberry the Erie blue clay. In the workings of the tunnel this clay has been found to be stratified throughout by innumerable very thin strata of dry quicksand. While the entire deposit is built up of alternating strata of quicksand and clay, yet there are some strata more distinctly defined than others. The strata of clay vary in thickness; but what appear to be the best de-

veloped strata of clay range from about three-fourths of an inch to one and one-half inches in thickness, or even more. This, however, is only the general appearance; for a closer observation shows that these strata, and, in fact, the entire body of clay, may be subdivided by bands of quicksand as mentioned above.

Some of the deposits of quicksand are plainly observable, as those which separate the clay into layers of about one inch in thickness. The thin seams of quicksand separating the clay vary, but they seldom measure three-sixteenths of an inch in thickness. The general thickness of the quicksand is from a sixty-fourth of an inch, or less, to an eighth of an inch. Often the seams are so fine that they are not visible to the unaided eye. But taking the clay and pulling it at right angles to the line of stratification will divide it perfectly along the strata as if cut with a knife. At times sheets of clay from one to several inches in thickness fall from the roof of the tunnel like broad strips of rubber belting. The clay is very tenacious and can be peeled off the roof by the yard in almost any desired thickness, like the bark from a tree.

The strata are horizontal in the greater part of the workings, but places are found where they have been more or less disturbed by wave action. Some places show cross bedding, and others are much folded.

In no place has anything but stratified material been found, and that of the finest composition. At a few places fine sand has been found; but they appear mainly as pockets. The amount of quicksand which enters into the composition of the body of the clay varies somewhat from point to point; but where more than the normal amount is present it becomes what is termed "short," i. e. it breaks readily and is not easily supported by the compressed air.

It may be stated here that all work is done under a pressure of about two atmospheres. This supports the clay in the roof and keeps it from coming in at the face, besides keeping in check the gas which is found more or less throughout the clay.

The following analyses were made by Prof. A. W. Smith, of the Case School of Applied Sciences, Cleveland. No. 1 is

quicksand, 7,900 feet from the shore. No. 2 is clay from the same place. No. 3 is clay, 19,600 feet from the shore.

		No. 1.	No. 2.	No. 3.
Combined water	H_2O	6.40	7.60	7.57
Total silica	SiO_2	62.50	60.60	53.53
Quartz or free silica		29.3	....	32.5
Alumina	Al_2O_3	11.30	16.20	23.76
Iron oxide	Fe_2O_3	6.52	2.60	2 15
Calcium oxide	CaO	7.25	5 05	7.16
Magnesium oxide	MgO	1.75	3.00	3.06
Potassium oxide	K_2O	2.20	2.20	.24
Sodium oxide	Na_2O	1.30	1.01	.46
Sulphuric anhydride	SO_3	.27	.72	1.63
Carbonic "	CO_2	.15	.32	.64
Titanium oxide	TiO_2	.60	.27	.20
		100.24	99.57	100.40

Glacial Material.

Quite a number of fragments of rock, both glaciated and unglaciated, have been found. None of these have exceeded eighteen inches in longest diameter, the majority being much smaller. None have been much less than two inches in diameter. Many were more or less rounded and smoothed by the action of water; some were very roughly angular, showing no glacial or water action at all; others showed very perfect and deep striæ on two or more sides.

The distribution of the rock fragments has been quite uniform, but somewhat more frequent near the shore than a few miles out. At no place could they be said to be plentiful. They varied much in material; many were syenites, and, with the exceptions of the shales and sandstones, they were of foreign origin. Though fine gravel or coarse sand was found in a few places, it is a noticeable fact that the rock fragments and the gravel (or more properly sand) did not grade into each other.

An Old River Channel.

The records of the Cleveland Water Works Department in Volume 16, contain some interesting information in regard to the two nearly parallel tunnels, each about one mile and a quarter in length, which are now in use, completed respectively in 1874 and 1890, situated close west to the Cuyahoga river

mouth. In the construction of one of these tunnels, what was apparently the channel of the old Cuyahoga was found at a depth of about eighty-five feet below the surface of the lake.

A description of the preglacial valley of the Cuyahoga river was given in the AMERICAN GEOLOGIST, September, 1897. By way of explanation to the following, it may be stated that the records of numerous wells drilled in Cleveland and vicinity, show a deep V-shaped preglacial valley emptying into lake Erie. The deepest part of this old valley, as determined by its rock walls and bottom, is about three and a half or four miles east of the present mouth of the river, and has a depth of about 450 feet below the lake level. The east side of this old valley is quite abrupt. From the deepest part its west side rises gradually and outcrops a short distance beyond the mouth of the river. This preglacial valley has been traced back from the lake front about nine miles. It is now entirely filled with a sedimentary deposit, over and through which the present river flows. It is probably in this deposit which extends under lake Erie that the old river course was discovered. This old channel, which is described below, is over eighty feet below the present lake level.

The best idea is obtained from a part of the report of Volume 16, as follows:

"When the test holes were bored in the clay along the line of the tunnel, care was taken to sink them far enough away from the proposed line to avoid any danger of running the tunnel near them, in case the crib could not be located upon the spot designated. The outer boring was made about 300 feet westerly from the crib, and the clay brought up was of the best quality for tunneling in; and that under the crib is believed to be only a pocket or narrow valley in the original deposit, subsequently filled by clay sediment, and not yet solidified, though having precisely the same appearance as the harder clay when dried. In building the shore end of the tunnel two such deposits were passed through, the soft deposits first appearing at the top of the excavation, and inclining at such an angle that after digging but a few feet the whole excavation was in this soft clay; this was continued (with the exception of a narrow ridge or island of hard clay reaching to about the center of the tunnel) for a distance of about 300 feet

when the hard clay was again met with at the bottom of the excavation, and leaving the soft clay at an angle inclined in an opposite direction from that in which it was entered. The second deposit of this character was entered and left the same as the first, the second being a little longer than the first.

"The horizontal direction of the first deposit was from southeast to northwest, and that of the second deposit was from southwest to northeast, the sides forming what appear to have been the banks of an old water course. The clay under the crib being the same as found nearer shore in this valley leads to the belief that it rests on the deposit filling this old channel."

The soft material on which this crib rests is well shown in the fact that during a storm shortly after it was placed, it sank eleven feet in one night, and has settled over thirteen feet in all.

The clay through which both the old tunnels were excavated is reported to have been unstratified, except at the localities noted as parts of an old river channel. But the new tunnel passes all the way, nearly five miles, in stratified clay; and the shaft at the new intake crib was wholly in stratified clay from the lake bed to the bottom of the tunnel, fifty-three feet. The old tunnels are at the upper part of the western ascending slope from the submerged continuation of the preglacial and drift-filled Cuyahoga valley; and the new tunnel lies nearly at the center, though not the deepest part, of that valley.

EDITORIAL COMMENT.

FUNDAMENTAL CHANGES IN THE ARCHEAN AND ALGONKIAN, AS UNDERSTOOD BY PROF. VAN HISE OF THE UNITED STATES GEOLOGICAL SURVEY.

The following extracts are from the twenty-first annual report of the United States Geological Survey, part 3, pp. 317 and 402, 1901. Their bearing on the differences that exist concerning these rocks between the United States and the Minnesota surveys is apparent to those who have been familiar

with the course of investigation of the geology of the Lake Superior region.

"The foregoing papers* render it unnecessary for me here to take up the general stratigraphy of the lake Superior region. However, our work north of lake Superior, in northeastern Minnesota and Canada, has upon two points modified our published conclusions as to succession and correlation. Those who compare this paper with other papers will note two important modifications. First, the Archean has heretofore been supposed to be composed wholly of igneous rocks, no sediments having been recognized in this divsion of the pre-Cambrian. The north-shore work, however, makes it very probable that certain of the sedimentary iron-bearing formations must be included in the Archean. As examples of such are the productive iron formations of the Vermilion and Michipicoten districts. This modification is important from a theoretical point of view, since it will make changes necessary in my general definition of the Archean and of the Algonkian. The Algonkian has been defined to include all pre-Cambrian sedimentary rocks. The Archean has been defined to include all pre-Algonkian rocks, and has been supposed to contain igneous rocks only. These definitions must be modified so as to include in the Algonkian all pre-Cambrian series which are dominantly of sedimentary origin or equivalent in age with those which are dominantly of sedimentary origin. The Archean must be defined to comprise the rocks older than the Algonkian which are dominantly of igneous origin, but which may include subordinate amounts of sediments. Recent work in northwestern Europe, and especially in Scotland, Scandinavia and Finland, where the ancient rocks are best exposed in Europe, shows that these modifications in the definitions of the Archean and Algonkian are also there applicable. The changes are quite in line with what might be expected, for in recent years no one feature in geological advance has been more significant that the sweeping away of sharp dividing lines between the various periods.

"Second, the iron-bearing formations of the Vermilion and similar districts I have heretofore regarded as Lower Huronian. In placing these formations in the Archean I recognize three series in which productive ore formations are found, the Upper Huronian, the Lower Huronian, and the Archean

"The evidence upon which these modifications of my opinion concerning the Lake Superior stratigraphy are based cannot be here presented in detail. It will be fully given in a monograph on the Vermilion district to be published later. In general it may, however, be stated that our work in the Vermilion district of Minnesota and on the Canadian side of the international boundary has convinced us that bands of sedimentary iron-bearing formation are interstratified with the upper part of the oldest series of the Lake Superior region, composed of greenstones, greenstone schists and tuffs, although the thick productive beds of the Archean appear to rest upon the greenstones and greenstone schists." * * * * * * *

* A list of the publications of the United States Geological Survey respecting the formations and iron ores of lake Superior. [N. H. W.]

The succession of formations above given differs from that which I supposed would be found before the Vermilion district was studied in detail. I had supposed that the Animikie series was equivalent to the series here placed in the Lower Huronian. When the relations were first studied in the field by the members of the United States Geological Survey, Mr. Clements and Mr. Leith thought that the relations of the two series was those of unconformity. When I reached the field later and saw the same facts, I was inclined to believe that the phenomena were more likely to be explained by overlap. However, in the season of 1900, when Mr. Leith began studies upon the Mesabi district, he showed that the Mesabi series, which is undoubtedly the equivalent of the Animikie series, with gentle inclination rests unconformably upon vertical slates and conglomerates equivalent to the Knife Lake slates and Ogishke conglomerates. I have therefore no doubt that the correct interpretation of the phenomena in the Vermilion district is that of unconformity between the Animikie series and the Lower Huronian series.

"Before closely studying the Vermilion district in the field, supposing the two series to be the same, I also thought it probable that the iron-bearing formation of the Vermilion would turn out to be the equivalent of the Lower Huronian iron-bearing formation of the south shore of lake Superior in the Marquette district. But very careful work by Messrs. Clements, Merriam, Leith and myself has failed to discover any great structural break between the Soudan formation and the great Ely greenstone formation which is undoubtedly Archean. Therefore we now recognize an iron-bearing formation in the Archean. Here, as elsewhere in the Lake Superior region, there is great unconformity between the basal Archean complex, consisting mainly of granites, gneisses, greenstone schists, and greenstones, but containing subordinate amounts of sediments, and the sedimentary series of the Lower Huronian."

These modifications, barring differences of nomenclature, constitute an important step toward concordance respecting the general geological structure of northeastern Minnesota, between the United States and the Minnesota surveys. The study and interpretation of the geology of the Lake Superior region, and of the iron ores found on both sides of that great depression, is a very arduous and complicated undertaking. There is no reason to expect complete agreement between the observers who work on the different parts of the problem, even when they examine the same facts at distant points. Northern Minnesota is a district in which the oldest rocks can be studied with exceptional ease. The classification which may be ultimately evolved when they are fully worked up, in connection with the adjacent portions of Canâda, will be likely to stand for many

years as the American standard for those rocks. There is no doubt that numerous errors will be committed in the first announcements by the various surveys, and by the partial investigators, necessitating modifications when they shall be discovered. It is to be hoped that all will be as ready to admit changes in their interpretations when convinced of error, as is Prof. Van Hise. At a future occasion the writer will perhaps call attention more in detail to the effect of these modifications.

N. H. W.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

A Treatise on Zoology. Edited by E. RAY LANKESTER. *Part III. The Echinoderma,* by F. A. BATHER, assisted by J. W. GREGORY and E. S. GOODRICH. (A. and C. Black, London, 1900. pp. i-viii, 1-344.)

The student of zoology, if he wishes an elementary text-book, finds as great difficulty in making his selection as he does in buying a new bicycle or typewriter. Apparently the more advanced student will not be thus hampered by an embarrassment of riches, for it is doubtful whether any work aims as high and attains as much as the volume under review.

The average worker who has added somewhat to his primary zoological training finds it a dreary and often fruitless performance to extract the new facts of science or the present state of knowledge on any particular topic from the almost endless collection of "elementary" text-books, no matter how valuable they may be in fulfilling their true function. It is almost equally tiresome to sift out the same information from the great mass of technical papers on particular things. The present volume supplies in a large degree this deficiency for the Echinoderma, and is a most welcome addition to general zoological literature. The entire series is planned to include ten parts, of which this is the third. Each of the larger groups of animals is to be described by a separate author after a definite model, in order to secure uniformity both in scope and method.

The general systematic survey of the phylum Echinoderma, with its seven classes, is quite full and comprehensive and includes the main facts of ontogeny, phylogeny, anatomy, and classification. The orders and families are all clearly defined and most of the prominent genera are reviewed and mentioned. One of the striking features of this volume is the fullness with which the fossil forms are treated, thus

according them their true value in any general treatise on echinoderm morphogeny. Instead of the starfishes and sea-urchins constituting the entire program, or "whole show," as they do in the minds of the average student and in half of the text-books, here they form but the last two of the seven classes recognized, and the length of their discussion is in proper proportion. It is sincerely to be hoped that similar true values will be given among other classes, whether extinct or not.

The phylum Echinoderma comprises two divisions or grades, the Pelmatozoa and the Eleutherozoa. In the first are the classes Cystidea, Blastoidea, Crinoidea, and Edrioasteroidea. In the second grade are the Holothuroidea, Stelleroidea, and Echinoidea. This arrangement shows the unequal value of the classes and does not express their phylogenetic relations. The latter probably would be more truly represented, according to Bather, by placing a primitive class, Amphoridea, at the base and deducing from it several lines of descent; namely, Edrioasteroidea, Anomalocystida, Aporita, Rhombifera, and Diploporita. From the Edrioasteroid line, it is supposed, there sprang first Holothurians, then Stelleroidea, then Echinoidea. The blastoids are included in the Diploporite line, and from them as a fresh development with a new lease of life arose the important class Crinoidea, whose discussion occupies, as is wholly proper, nearly one-third of the present volume.

The class Stelleroidea comprises the Asteroidea and Ophiuroidea, generally considered as quite distinct. Some recent genera, however, and many of the fossil forms show that no clear line of separation can be drawn, though the names are still retained for simple convenience.

The usual primary subdivisions of the Echinoidea into two subclasses, the Palæechinoidea and Euechinoidea, have been abandoned and the older divisions Regularia and Irregularia adopted. The primitive ancestral Echinoid is unknown, though it is evident that the first forms were small sac-like bodies, with the mouth and arms at opposite poles and the muscular body supported by a series of angular plates, of which five pairs were perforated by pores. The thickening of the plates and the consequent loss of flexibility is believed to explain the reduction in the number of vertical rows taking place in the passage from paleozoic to neozoic genera. C. E. B.

Recently Discovered Extinct Vertebrates from Egypt. By CHAS W. ANDREWS, D. Sc., F. G. S., of the British Museum. (The Geological Magazine, September and October, 1901.)

Northern Africa has long been regarded with peculiar interest, for the reason that the geographical distribution and stage of development of many Recent and Cænozoic vertebrates, gave evidence that Africa was a centre in which they evolved and from which they migrated. Through the courtesy of the Egyptian Survey, Mr. Andrews has visited the Libyan desert, with eminently satisfactory results.

The formations extend from Eocene through Pliocene, and contain

a large number of fossiliferous horizons. Mammals, reptiles, turtles, crocodiles, and fishes were found in large numbers.

Among the most interesting of these discoveries is a (presumably) Lower Oligocene proboscidian, for which Mr. Andrews proposes the name *Palaeomastodon beadnelli.* The Proboscidia are a most extraordinary group in point of specialization, their tooth and foot structure being unique in the animal kingdom. The Lower Miocene of Europe has long been noteworthy for the first appearance of the group in a highly specialized form, *Mastodon angustidens.* It is of great interest to find that *Palaeomastodon* presents a tooth structure of much greater simplicity and more generalized type than this most primitive previously known proboscidian. Other members of the group were found, and we may henceforth look upon northern Africa as their centre of radiation.

The evolution of the African fauna is entirely independent, the animals differing from those found in deposits of the same age in Europe. The existence of a large and long isolated land area to the south is thus indicated.

I. H. O.

Ueber die Entwickelung der Silurischen Sedimente in Böhem und in Sudwesten Europas, von FRITZ FRECH, mit 6 fig. (Neuen Jahrbuch für Mineralogie etc., Jahrg. 1899, Bd. ii.)

This article collates from various sources (the works of Barrande Bergeron Barrios Brögger, etc.) information gathered as to the changes of the Silurian and Cambrian sediments in various parts of western Europe.

The author describes a continental area extending from north of Bohemia through France and Spain where no upper Cambrian sediments have been found as separating two marine areas in the N. W. of and the S. E. of Europe respectively. Over this island by transgression in Lower Ordovician time the sea gradually spread introducing the great Asaphi and eventually the Calymmenidæ into areas which previously had only coarse sediments, conglomerates, grauwackes and coarse sandstones. The depression went on until abysmal forms like the graptolites and the radiolarians appeared and spread over wide areas, especially in England, France, and the eastern Alps as well as the northwestern or Scandinavian sea of that period. The article discusses and approves of Dr. Brögger's determinations of the equivalent of the Ceratopyge fauna (Tremadac) with his interpretation of the genera mentioned in the works of Barrois, Bergeron, Salter and others who have studied the faunas of this period of Palæozoic time.

G. F. M.

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CORRESPONDENCE.

WHEN WAS THE MISSISSIPPI RIVER VALLEY FORMED? The age of the Mississippi river seems to be sometimes a question. On the flood plain and along the bluffs at Clinton and Davenport, Iowa, and at numerous other places are deposits of the Carboniferous like the under clay of the Illinois coal fields, evidently remnants of the lower coal formation which was deposited and then swept away by the river when an elevation occurred. The town plot of Clinton is filled with these pits, which are uncovered in making foundations. Some deep pits were excavated in making the foundations for the Rock Island government works some years ago.

Prof Hall in the first volume of Iowa geological reports noticed this, and gave some figures. One was shown in a quarry at Rock

Island, opposite Davenport, in the Le Claire limestone. "In the midst of this was the impression of a large *Euomphalus* distinct from any known in the surrounding rocks and very similar to a Carboniferous form, x x. The conclusion seems therefore irresistible that subsequent to the uplifting of these rocks and their denudation, the materials of the coal measures were deposited upon the surface of the older rocks."* He cites several other instances. At Clinton these pockets of Carboniferous clay are frequent in the quarries at the bluff and in pits found in every direction where the rock is uncovered on the town plot. The crevices and cavities in the quarries were filled from the top about fifty feet above the present river. In one observed there was a chimney opening down to a large cavity, extending across the quarry, a hundred feet or more. There were also numerous smaller pits in the vicinity, in which the clay looked like cannel coal and had fragments of carbonized wood in it. The larger cavity was excavated for pottery clay. There were no fossils found except some pieces of pryritized wood. The darkest material put into the fire turned very red from the large portion of oxide of iron. A large deposit of this clay was found at the foot of another quarry.

My attention has been called several times to indications of supposed coal mines in the deep channels of streams that run into the river. Pits were filled with coal-like clay similar to that above described.

The openings of these crevices in the bluff are fifty or sixty feet above the river, 575 feet above sea level, say 635 feet.

This shale and a Carboniferous sandstone with traces of Carboniferous fossils have been traced into Jones county, twenty or thirty miles north. In fact it has been found in counties farther north. The flood-plain of the Mississippi at Clinton is 200 feet below the prairie level. A subsidence of a hundred feet would cover these deposits. At Rapids City, thirty miles below Clinton, coal is mined, its under-clay resting on the Niagara rock on a level with the flood-plain of the river. The subsidence of a hundred feet allowed the Carboniferous sea to flow up the river valley and cause the deposit of the Carboniferous material of that period. It is therefore obvious that the valley is pre-Glacial by a long period.

The record is much more ancient. It has been demonstrated that the original surface of Iowa was furrowed by deep channels and great denudation, probably in the Devonian age. Deep wells 300 feet or more in the drift, and mounds capped with the Niagara limestone near Dubuque and Galena, are evidences of the great erosion. The singular region called the driftless area in the corner of Iowa and Wisconsin, is probably a fair representation of the land surface of this middle west in Paleozoic times. This driftless portion is cut into conical hills 200, 300 and even 500 feet high, divided by ravines and canyons, the streams of which have cut channels down to the level

*Hall's Iowa Reports, vol. i, p. 130, 1858.

of the Mississippi valley and have filled up fiords at their mouths of unknown depth. The drift has covered the rest of the country higher than these hills.

Spencer has demonstrated from the deep channels at the mouth of the St. Lawrence, traces in the gulf, and the continuation of the Hudson river in New York bay, and from other data, that the eastern part of the continent once was very greatly elevated, when its rivers cut deep canyons and fiords similar to the canyon of the present Colorado. Then a depression and submersion, out of which not all the coast was raised.

The evidences are that the interior of the continent was also elevated after the Devonian period, and was washed by great denuding and erosive floods. The Mississippi valley has survived as the great water way of succeeding ages, while others have been filled. This is the inference, to some extent, of Prof. Chamberlin, who says, "the course of the Mississippi river is along the shore of the Devonian sea.* The present channel of the Mississippi is from 100 to 200 feet above its ancient bed. A deep boring at La Crosse showed sand and loose material to the depth of 147 feet. Rock river at Janesville is at least 250 feet above its ancient valley." At Clinton soundings for the railroad bridge went through sand and gravel 80, 100 and 150 feet to the rock below the water. The ancient channel is the sand plain beyond and has been sounded for more than 200 feet. A buried ravine runs through the town plot of Clinton, which has been explored for foundations to the depth of 100 feet without reaching the bed rock. Prof. Chamberlin says, "the cutting down of the ravines in the driftless area began in the early Devonian age† and was evidently a period of elevation. A subsidence took place at the beginning of the Carboniferous period, and to such an extent as to make a lagoon or placid bayou of the river valley up to and beyond Dubuque. In this quiet water was deposited clay and vegetation that forms coal. Its depth was approximately a hundred feet. A moderate elevation ensued which brought the valley to its present level and the coal formation was swept away, excepting only the traces left in these fissures and pits.

The most interesting geological history of the Mississippi valley is yet to be written. It has only been touched on here and there. It was a great river on an elevated plateau on the Niagara in this vicinity, at the close of the Devonian period. It fell into the gulf of Mexico at the mouth of the Ohio. It cut a broad deep valley varying from two to ten miles wide. The river itself is wider where tributary rivers check the current. The valley grows somewhat narrower near Dubuque, above which it has the same depth but is somewhat more regular in its outline. It is thence a grand Niagara river gorge on a grand scale, to St. Paul.

The glacial era, at its close, left its marks on many places in the

*Wisconsin reports, vol. i, p. 253.
†*Geology of Wisconsin*, vol. i, p. 153.

river valley. It was filled with ice to the prairie level. When the ice melted and the higher land appeared, the water cut new channels along the border in many places; notably at the upper and lower rapids, and further down. The "old father of waters," has not had sufficient time or force to deepen these channels. It is on these incomplete cuttings that the United States government is spending large sums of money. At the closing up of the ice-period many of the tributary streams also lost their old courses and cut new ones. This is the situation of many of the rivers of Iowa which has puzzled observers.

P. J. FARNSWORTH.

Clinton, Iowa, Oct. 12, 1901.

RECENT DECLINE IN THE LEVEL OF LAKE NICARAGUA.—About a year ago (October, 1900), Mr. J. Crawford published a letter in the American Geologist in which criticism is made of Dr. Heilprin's claim that the water-level in lake Nicaragua had fallen 20 feet between the years 1880 and 1898. In the course of his criticism Mr. Crawford says: "If between 1880 and 1898 there has been a decline of 20 feet from the 1880 level of lake Nicaragua from any cause, then the beach marks of the 1880 level would be easily found along the borders of the lake. But there is no such evidence to be found." While I have no data which would enable me to discuss the time-element in controversy, I did secure evidence, during my visit to Nicaragua in 1892-3, of a comparatively recent subsidence of the level of lake Nicaragua, and discussed it briefly in a paper published in 1896.*

It may be of interest, even at this late day, to quote the paper in question:

"The peculiar exposure of which notice is here made is found on the Manuel Vargas ranch, east of San Carlos, Nicaragua, on the south bank of the San Juan river. The river, here only twelve miles from the outlet of lake Nicaragua, flows due east and cuts into a terrace on the southern shore, forming a vertical bank which gradually rises from the low river-bottom at its eastern extremity, and reaches a height of more than fifteen feet at the western extremity of the shell-bearing portion. This bank, for one hundred yards from its eastern extremity, consists of fine alluvium which is literally packd with Unio shells, frequently cemented together by calcareous tufa into large masses.

"The shell-bearing portion of the exposure averages about twelve feet in height, but the surface of the ground gradually rises back from the river, and shells were traced along the surface to a point more than one hundred and fifty feet from the shore, this point being fifteen or twenty feet above the river which had then (March 12th, 1893) not yet reached its lowest stage. This indicates a total thickness of the deposit of more than fifteen, and probably not less than twenty feet.

"There are three species of *Unio* in the series of shells collected from the bank, and they are identical with living species found now in the mud of the river at the foot of the exposure. Many of the fossil shells still

**Bull. Lab. Nat. Hist., State Univ., Iowa*, vol. iv, pp. 94-95. A Nicaraguan Shell-bank.

have their valves united by the ligament, and not a few are in a vertical position, showing that the shells had been deposited *in situ*. These species are now found living in abundance in the river in the mud close to the shores, and the fossil shells no doubt were developed under similar conditions.

"The conclusion naturally follows that at one time the San Juan river and, of course, lake Nicaragua, of which it is the outlet, had their low water mark more than fifteen feet above the present level; that the river has since cut through the eastern barriers to its present level, in its downward progress gradually depositing an oblique sheet of shell-bearing alluvium; and that the level of the lake has correspondingly fallen. Lake Nicaragua is today more than one hundred feet above sea-level. The San Juan river therefore has sufficient fall for further effective erosion, which is, without doubt, going on at an increasing rate, and the conclusion seems irresistible that the lake is destined to a further reduction of its level, and a still further contraction of its area, and that within no distant future; since it is evident from the comparatively perfect preservation of the shells above mentioned that the whole shell-bank is a very recent affair indeed, as terrestrial changes go.

"In view of the attempted construction of vast public works along the valley of the San Juan river, the importance of this conclusion is sufficiently obvious.

"While the lake cannot be wholly drained, its greatest depth being about two hundred and forty feet and the elevation of its surface above sea level being one hundred and ten feet, its average depth is such that a comparatively slight fall in its general level must cause a great contraction of its area—a circumstance of much importance to the cities and towns along its shores.

"The building of the proposed great Ochoa dam across the lower San Juan river in connection with the construction of the Nicaragua canal is probably the only thing that would arrest this erosion, and would secure the retenton of this vast and important inland reservoir of fresh water."

All that part of the river valley lying above the point here discussed was evidently at no remote time covered by the waters of the lake which have since receded to San Carlos because of the lowering of the river channel and consequently of the lake level.

The deposit of shells here discussed is not to be compared with the shell heaps sometimes found along shores, but was evidently formed gradually, and represents an old Unio bed.

In considering the extent of the change in the altitude of the water-level in the lake, which is shown by this deposit, it must be borne in mind that to live Unios must be constantly submerged, and that therefore the highest portion of the shell-bank represents what at one time was less than the lowest stage of water in the lake. It is true that these Unios (fresh water mussels) are capable of creeping about more or less, but nowhere do whole colonies of them move upward with the floods, to be stranded when the waters again recede.

Whatever may be the exact dates or altitudes involved, it is certain that the waters of lake Nicaragua have subsided in comparatively recent years, and that the way to save lake Nicaragua is to construct the great canal. B. SHIMEK.

State University of Iowa, Nov. 25, 1901.

PERSONAL AND SCIENTIFIC NEWS.

DR. H. M. AMI, of the Geological Survey of Canada, who sustained a rather severe injury to hs left arm and shoulder last September, from a fall down the steep cliff at Cap à L'Aigle below Quebec City, is sufficiently recovered to resume his official duties at Ottawa.

DR. THOMAS L. WALKER, of the Geological Survey of India, and formerly lecturer in Toronto University, has been appointed professor of Mineralogy and Petrography in the same university. Authorities at Toronto University have not yet selected from the many candidates the man to fill the vacant chair of Geology and Paleontology.

GEOLOGICAL SOCIETY OF WASHINGTON. On November 13th the following program was presented: "Pyrite and Marcasite," H. N. Stokes; "The Geographic Features of New Mexico," R. T. Hill; "Occurrences of Petroleum in the Northern Rockies," Bailey Willis. The program for the meeting on Nov. 27th was devoted to "The Geology of Cuba," as follows: "Physiography," C. W. Hayes; "General geology and geologic history," T. W. Vaughan; "Economic Geology," A. C. Spencer.

LEHIGH UNIVERSITY is erecting a stone laboratory, 90 ft. by 43 ft. to be used in connection with the steam engineering work of the course in mechanical engineering. Next fall the university will offer a new and extended course in electro-metallurgy —the first of its kind, it is believed, to be established in this country. The departments of civil engineering and of geology have recently received valuable gifts in the shape of surveying instruments, microscopes, and geological specimens for the microscopic study of rocks.

IN NOVEMBER DR. J. W. SPENCER left Toronto with Mrs. Spencer to spend several months in Mexico and Central America, intending to return to Washington about May 1. The object of his travels is to make further investigation of the plateau forms, valleys and cañons for the purpose of comparison with the drowned features of the West Indian region. He had previously discovered the geological canal and the proof of a very late Pleistocene shallow water connection between the gulf of Mexico and the Pacific. It is over the isthmus of

Tehauntepec. The gravel plain of the floor is now raised up 800 feet. This canal is a mile long, 150 feet deep, and narrow, with its floor covered with rounded gravel, which merges into a terrace on the gulf side.

An Interesting Intercollegiate Excursion of teachers and advanced students, under the guidance of professor W. M. Davis, of Harvard University, was made on October 19th to the river terraces in the Westfield river valley, in Massachusetts. The particular aim was to work out the control of rock ledges upon the distribution and topography of the terraces. Forty-six persons were present, representing twelve institutions. The success of the trip has encouraged its promoters to hope for others in 1902, to bring together members of the various higher institutions of learning in New England.

The Field Work of the First Year Research Course in geology at Harvard University, for this year, is an elaboration of that begun two years ago. At present eighteen men are engaged in a geological survey of the metropolitan district of Boston, including the Boston Basin and its surrounding igneous and sedimentary rocks. The members are acting as volunteer assistants on the U. S. Geological Survey, under Dr. T. A. Jagger, Jr., as a regular office of the survey; and the work, which is based upon recent detailed topographic mapping of the survey, is submitted with a view to ultimate publication by that organization, as folios or reports. The nine field parties cover territory stretching from Marblehead on the north to Nantasket on the south, and from the ocean west to Bedford and Dover.

Geological Explorations near Athens. The British Museum during the past summer has obtained some important fossils of tertiary mammals at Pikermi, near the Marathon road, about twelve miles from Athens. The specimens were found at a considerable depth below the bed of a mountain torrent, and were so jammed together that evidently the animals were buried alive, probably by torrential action. About fifty years ago Dr. Albert Gaudry in this locality obtained a great number of fossils for the Paris museum. Since then the Vienna academy has made a similar collection; but until the present year the British museum had sent no expedition to this field. Among the principal finds were numerous bones of *Hipparion, the* three-toed predecessor of the horse; *Helladotherium,* a short-necked giraffe allied to the *Okapi,* the new mammal recently discovered by Sir Henry Johnston in the forests of the Kongo state; several skulls of *Mastodon,* and skulls, teeth and bones of the great saber-toothed tiger *Machaerodus,* specimens of which have been found in England. One of the prizes was the remains of perhaps the largest tortoise ever found in Europe. Very few bones of rodents or of birds were found, but a considerable collection of land shells was obtained. Dr. A. S.

Woodward, who was in charge of the excavation, has forwarded to the British museum forty-seven large cases of fossils.—*Nat. Geog. Mag.*

I HAVE BEEN UNABLE TO OBTAIN positive proof of the discovery of any implements used by man in gravels covered by so-called lavas, or human remains in auriferous deposits in place in any part of California. I have for years kept this matter in view and eagerly sought information when discoveries were announced, but have met with an insurmountable doubt when the evidence was carefully investigated. The same uncertainty applies to discoveries made at the bottom of vertical shafts, for surface objects may accidentally fall or be thrown into them purposely. H. G. HANKS.

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